2.0 PROBLEM IDENTIFICATION

2.1 CAUSES OF COASTAL LAND LOSS AND ECOSYSTEM DEGRADATION

In preparation for subsequent discussions of existing and future without-project conditions, a summary of the major factors that contribute to coastal land loss and ecosystem degradation in Louisiana is necessary. While many studies have been conducted to identify the major contributing factors (e.g., Boesch et al. 1994; Turner 1997; Penland et al. 2000a), most studies agree that land loss and the degradation of the coastal ecosystem are the result of both natural and human induced factors, which interact to produce conditions where wetland vegetation can no longer survive and where wetlands are lost. Establishing the relative contribution of natural and human-induced factors is difficult. In many cases, the changes in hydrologic and ecologic processes manifest gradually over decades and in large areas, while other effects occur over single days and impact relatively localized areas. For barrier shorelines, complex interactions among storm events, longshore sediment supply, coastal structures, and inlet dynamics contribute to the erosion and migration of beaches, islands, and cheniers.

The measurable increase in coastal land loss in the mid- to late- 20th century can be linked to human activities that have fundamentally altered the deltaic processes of the coast and limited their ability to rebuild and sustain it. In the Chenier Plain, human activities have fundamentally altered the hydrology of the area, which has impacted the long-term sustainability of the coastal ecosystems. Because of the magnitude and variety of these human-induced changes, and their interaction with natural landscape processes, all of the factors contributing to coastal land loss and ecosystem degradation must be viewed together to fully understand how Louisiana's coastal ecosystem shifted from the historical condition of net land gain to the current condition of accelerated net land loss.

2.1.1 Natural Causes Influencing Coastal Land Loss and Ecosystem Degradation

The following discussion identifies those predominantly natural factors of coastal land loss and ecosystem degradation. However, these factors are intrinsically linked with human factors of land loss and ecosystem degradation due to man's overwhelming influence over the natural system. Geologic faulting, compaction of muddy and organic sediment, river floods, global sea level change, wave erosion, and tropical storm events have shaped the coastal Louisiana landscape for thousands of years (Kulp 2000; Reed 1995). Over millennia, sea level change and subsidence were offset by delta building in the Deltaic Plain and mudstream accretion in the Chenier Plain. Erosion of barrier shorelines and disruption of fragile organic marshes by tropical storm events resulted in land loss, but also contributed to habitat and wildlife diversity. There is little direct evidence that any of these natural processes changed in the mid to late 20th century. The following is a brief summary of the natural factors contributing to land loss.

2.1.1.1 Barrier island degradation

Barrier islands are important elements of the geomorphic framework of the estuary. Barrier islands separate the gulf from the back-barrier estuarine environment helping to maintain the salinity gradients important to estuarine species. As islands erode and are breached, marine forces are allowed to affect the interior boundaries of the estuaries, thereby accelerating land loss. Barrier islands also serve as valuable storm buffers protecting communities, industry, and associated infrastructure from storm surges.

Barrier island degradation is a natural process and represents the latter phase of the deltaic process, as described in section 1 INTRODUCTION. Marine influences, particularly those associated with tropical storm events, gradually erode and rework the structure of the islands until they eventually disappear. While the acreage amounts associated with the loss of barrier islands may not contribute appreciably to the total acreage of land loss in the study area, their disappearance can result in significant and profound impacts on coastal land loss and ecosystem sustainability. Barrier islands serve as natural storm protective buffers and provide protection and limit erosion of Louisiana's coastal wetlands, bays, and estuaries, by reducing wave energies at the margins of coastal wetlands. In addition, barrier islands limit storm surge heights and retard saltwater intrusion. The historic rates of land loss for Louisiana's barrier islands are varied, and can average as high as 50 acres per year (20.3 ha per year), over several decades. Hurricane events can push the rate of land loss to surpass 300 acres per year (122 ha per year). For example, the Isles Dernieres have decreased in acreage from approximately 9,000 acres (3,645 ha) in the late 1880s to approximately 1,000 acres (405 ha) by 2000 (see appendix D LOUISIANA GULF SHORELINE RESTORATION REPORT).

2.1.1.2 Tropical storm events

Tropical storm events can directly and indirectly contribute to coastal land loss through a variety of ways: erosion from increased wave energies, removal and/or scouring of vegetation from storm surges, and saltwater intrusion into interior wetlands carried by storm surges. These destructive processes can result in the loss and degradation of large areas of coastal habitats in a relatively short period of time (days and weeks versus years). Since 1893, approximately 135 tropical storms and hurricanes have struck or indirectly impacted Louisiana's coastline. On average, since 1871, a tropical storm or hurricane affects Louisiana every 1.2 years.

2.1.1.3 Eustatic sea level change

Eustatic sea level change is the global change of the oceanic water level. Data indicate that concentrations of greenhouse gases (e.g., carbon dioxide), and global temperatures have increased during the 20th century. As a result, eustatic sea levels are expected to rise in the future at a higher rate than observed during the 20th century. EPA (1995) estimated that global warming is likely to raise global sea levels 5.9 inches (15 cm) by the year 2050 and 13.4 inches by the year 2100 (34 cm). Other experts predict that the level of the world's oceans could rise over 8 inches (20 cm) over the next 50 years.

2.1.1.4 Relative sea level change

Along the Louisiana coast, both changes in water level and changes in land elevation are occurring. Relative sea level change is the term applied to the difference between the change in eustatic sea level and the change in land elevation. Relative sea level change is also referred to as relative subsidence.

Land elevations decrease due to subsidence from compaction and consolidation of sediments, faulting, and groundwater depletion. Recent studies have shown that subsurface fluid (e.g., oil and gas) withdrawal may also be a contributor, but the magnitude of its contribution is not well understood (Morton et al. 2002). Land elevations increase due to sediment accretion from riverine and littoral sources and organic deposition from vegetation. For most of coastal Louisiana, sediment accretion is insufficient to offset subsidence, causing land elevations are decreasing.

Changes in land elevation vary spatially along coastal Louisiana. In areas where subsidence is high and riverine influence is minor or virtually nonexistent, such as in areas of western Barataria Basin and eastern Terrebonne Basin, wetland habitats sink and convert to open water. Estimated subsidence rates for the Deltaic Plain are between 0.5 to 4.3 ft/century (0.15 to 1.31 m/century) and between 0.25 to 2.0 ft century (0.08 to 0.61 m/century) for the Chenier Plain.

Factoring in changes in land elevation and water levels, the average rate of relative sea level change along coastal Louisiana is currently estimated to be between 3.4 to 3.9 ft/century (1.03 and 1.19 m/century).

2.1.2 Human Activities Influencing Coastal Land Loss and Ecosystem Degradation

Human activities that have direct impacts on wetland loss often have indirect impacts.

2.1.2.1 Flood control

Following European settlement in coastal Louisiana, humans began to modify the Mississippi River. Levees were built and maintained to limit flooding of populated areas and agricultural areas, and to support interests such as navigation. Levees serve two general purposes: 1) contain river flows and 2) protect against storm surges. There are approximately 2,250 miles (3,622 kilometers) of levees that have been constructed in coastal Louisiana to contain the Mississippi River and its distributaries and to protect agricultural and urban areas from flooding. Numerous water control structures have been constructed related specifically to agricultural activities in the coastal zone as well resulting occasionally in impoundment of water. Several hurricane protection levee projects are in various stages of design and construction, including Morganza to the Gulf and Donaldsonville to the Gulf projects. These projects would upgrade or build new levees in the coastal area. An additional effect of these flood protection actions has been the facilitation of development throughout the coastal zone. Although the development of designated wetland areas are currently regulated this does not completely prohibited development. Perhaps more importantly, historically there was no prohibition for such development.

An unintended consequence of the construction of the levee system has been to accelerate coastal land loss and reduce the sustainability of the coastal ecosystem by reducing riverine influences to many of the coastal wetlands. In most instances, wetland habitats have become isolated from the freshwater, sediment, and nutrients of the Mississippi River and its distributaries. With a reduced or absent hydrologic connection to the river, marine influences in the areas can predominate. In the short-term, this influence can result in greater habitat and wildlife diversity, as well as some land loss. In the long-term, coastal habitats can disappear without a renewed or enhanced connection to freshwater, sediment, and nutrients.

2.1.2.2 Navigation

There are 10 major navigation channels, both deep draft and shallow draft, within the Louisiana coastal area. While these channels support the local, regional, and National economies, they also serve as conduits for saltwater intrusion in some areas and barriers to the distribution of freshwater, sediment, and nutrients to wetland habitats in other areas. For example, jetties adjacent to the Empire Waterway, Belle Pass, Mermentau River Navigation Channel, and Calcasieu Ship Channel trap sediment on the east side creating an erosional shadow to the west due to disruption of the natural sediment transport system. The navigation channels, such as the GIWW, also subject inland areas to more dramatic tidal forces and wave action, thereby increasing erosion.

2.1.2.3 Oil and gas infrastructure

With the discovery of oil and gas deposits in coastal Louisiana during the early 1920s, a vast network of canals, pipelines, and production facilities have been created to service the industry. Today, an estimated 9,300 miles (14,973 kilometers) of oil and gas pipelines crisscross the coastal wetlands of Louisiana. In addition, there are approximately 50,000 oil and gas production facilities located in the Louisiana coastal area. Canals that stretch from the Gulf of Mexico inland to freshwater areas allow saltwater to penetrate much farther inland, particularly during droughts and storms, which has had severe effects on freshwater wetlands (Wang 1987 and 1988).

Dredged material banks, which are much higher than the natural marsh surface, and the many smaller canals dredged for oil and gas exploration, alter the flow of water across wetlands. This hydrological alteration changes important hydrogeomorphic, biogeochemical, and ecological processes, including chemical transformations, sediment transport, vegetation health, and migration of organisms. Because of the presence of dredged material banks, partially-impounded areas have fewer but longer periods of flooding and reduced water exchange when compared to unimpounded marshes (Swenson and Turner 1987). This results in increased waterlogging and frequently in plant death. Importantly, dredged material banks also block the movement of sediment resuspended in storms, which play a major role in sustaining land elevations (Reed et al. 1997). By altering salinity gradients and patterns of water and sediment flow through marshes, canal dredging, which mostly occurred between 1950 and 1980, not only directly changed land to open water, but also indirectly changed the processes essential to a healthy coastal ecosystem. Elevated dredged material embankments may provide important wildlife refugia during storm events and valuable habitat for neotropical migratory birds, and the value of this habitat should be considered as restoration of these areas occurs.

2.1.2.4 Hypoxia

Hypoxia is a major environmental problem affecting coastal Louisiana and the northern Gulf of Mexico. It is also a problem of National importance, which will require action throughout the Mississippi River Basin to solve. While hypoxia is not a cause of land loss in coastal Louisiana, it is highly relevant to the broader coastal Louisiana ecosystem.

Hypoxia in the northern gulf is caused primarily by excess nitrogen in combination with stratification of gulf waters (CENR, 2000). For the period 1985 to 2001, the bottom area of the hypoxic zone ranged from 2,730 to over 7,700 square miles (7,070 to 20,000 square kilometers) (**figure MR2-1**) (Rabalais et al. 1999). The reduced hypoxic zone during years 1988, 1989, and 2000 are anomalies due to severe drought (i.e., significantly reduced water flows from the Mississippi River and its distributaries into the gulf).

The January 2001, “Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico” describes a National strategy to reduce the frequency, duration, size, and degree of oxygen depletion in the northern Gulf of Mexico. The Action Plan describes in general actions that are needed throughout the Mississippi River basin to address gulf hypoxia, including restoring de-nitrification and nitrogen retention in the coastal plain of Louisiana.

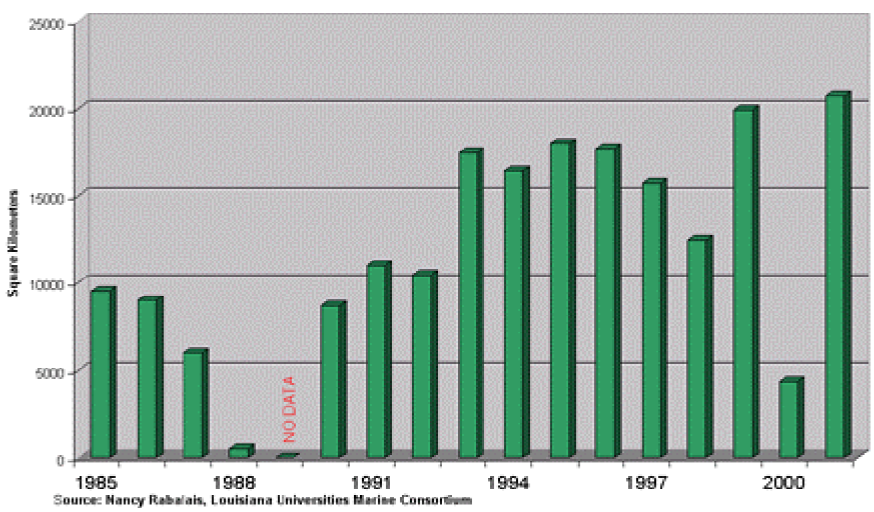

Figure MR2-1. Comparative Size of the Hypoxic Area from 1985 to 2001 (*source Nancy Rabalais, Louisiana Universities Marine Consortium*).

As described in section 1 INTRODUCTION, in the past, a portion of the Mississippi River's flow would occasionally divert into the coastal wetlands through crevasses or overbank flow. These flows into the wetlands would occur particularly during high river discharges when the maximum levels of sediment and nutrients were also being transported. These diversions would disperse a fraction of the sediment and nutrients into the wetlands, where the marsh vegetation would capture and incorporate them into the cycle of growth, thus reducing the total nutrient load reaching the gulf. Today, more nutrients pass though the study area and into the northern gulf as a result of the loss of wetlands (less wetlands to absorb the nutrients) and the significant reduction in hydrologic connectivity between the river and coastal wetlands (less ability to transport freshwater to wetlands that would absorb the nutrients).

2.1.2.5 Saltwater intrusion

Saltwater intrusion occurs when freshwater flows decrease in volume, allowing saltwater from the gulf, which is heavier than freshwater, to move inland or "upstream". Saltwater can then infiltrate fresh groundwater and surface water supplies, and damage freshwater ecosystems. The rate of saltwater intrusion depends on the amount of freshwater flows traveling downstream and the water depth in the wetlands, channels, and/or canals. Generally, high-inflow/low-salinity periods occur from late winter to late spring and low-inflow/high-salinity periods from late spring to fall. Saltwater intrusion is a principle factor in the conversion of freshwater habitats to saline habitats. Extreme salinity changes can stress fresh and intermediate marshes to the point where vegetation dies and the wetlands convert into open water (Flynn et al. 1995).

2.1.2.6 Sediment reduction/vertical accretion deficit

Vertical accretion of wetland soils depends on soil formation from sedimentary material of two types: mineral sand, silts, and clays brought in by river water, floodwaters, or winds; and living and dead organic matter produced locally by plants. In Louisiana, organic matter accumulation is frequently more important than mineral sediment input to vertical accretion (Nyman et al. 1990; Nyman and DeLaune 1991), except during initial phases of delta building (van Heerden and Roberts 1988). Accretion deficits in Louisiana coastal marshes are caused primarily by inadequate organic matter accumulation (Nyman et al. 1993). Any environmental change that lowers productivity or increases the rate of organic matter removal increases the vertical accretion deficit.

For those areas of active delta building, sediment from the Mississippi River and its distributaries is an essential ingredient in the land-building process. However, upstream reservoirs, changes in agricultural practices and land uses, and bank stabilization measures have reduced average sediment loads in the lower Mississippi River by approximately 67 percent since the 1950s (Kesel 1988).

2.2 EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS (NO ACTION)

The Louisiana coastal area is one of the most ecologically, economically, socially, and culturally diverse regions in America. The area includes extensive terrestrial, aquatic, and marine ecosystems, as well as adjacent agricultural, industrial, and urban centers. Forces that have shaped coastal Louisiana, both natural and human, have produced a delicate interdependency between man and the environment. Coastal Louisiana today can be characterized as a "working wetland" as life is closely linked to and depends on its resources. Louisiana's economic and cultural future is inextricably linked to the long-term sustainability of its natural environment.

Existing conditions in the Louisiana coastal area, as described in this section, can be attributed largely to changes in the management of coastal resources and processes. These changes provide for water control and the prevention of major floods, which historically precluded large-scale human settlement and economic development along the gulf coast, the Mississippi River, and its major tributaries and distributaries. Changes also included the creation of navigation channels and waterways across the coastal area, which provide for large-scale waterborne transportation of both commodities and finished products, and an extensive network of oil and gas canals and infrastructure.

While these activities have provided enormous benefits to Louisiana and have helped to build the Nation, they have also resulted in unforeseen consequences, such as coastal land loss. Today, the rapid loss of Louisiana's coastal wetlands and barrier islands has resulted in loss of environmental resources, population dislocation, and a growing threat to public safety and to billions of dollars worth of property and infrastructure. The future without-project conditions for the area, also known as "no action", forecast a continued trend of land loss and an associated decline in environmental and economic sustainability.

This section provides a description of the existing conditions and future without-project conditions for the Louisiana coastal area. Descriptions of existing conditions summarize physical, ecological, and socioeconomic conditions within the study area. Future without-project conditions describe what is assumed to be in place if none of the LCA Study alternative plans are implemented. Neither summary attempts to provide a comprehensive description of all resources or concerns; instead, both summaries focus on the most pertinent issues relevant to the implementation of a LCA Plan. A more detailed description of existing and future without-project conditions is contained in the final Programmatic Environmental Impact Statement (FPEIS).

2.2.1 Hydrology (Water and Sediment Transport)

2.2.1.1 <u>Existing conditions</u>

The Deltaic and Chenier Plains within the Louisiana coastal area contain all or part of 10 hydrologic regions including Pontchartrain, Pearl, Breton Sound, Barataria, Terrebonne, Atchafalaya, Teche/Vermilion, Mermentau, and Calcasieu/Sabine basins and the Mississippi River Delta (**figure MR2-2**). The basins within the Deltaic Plain are primarily influenced by the Mississippi River, while those in the Chenier Plain are not. As a result, the discussion of existing and future without-project hydrologic conditions addresses the Deltaic and Chenier Plains separately.

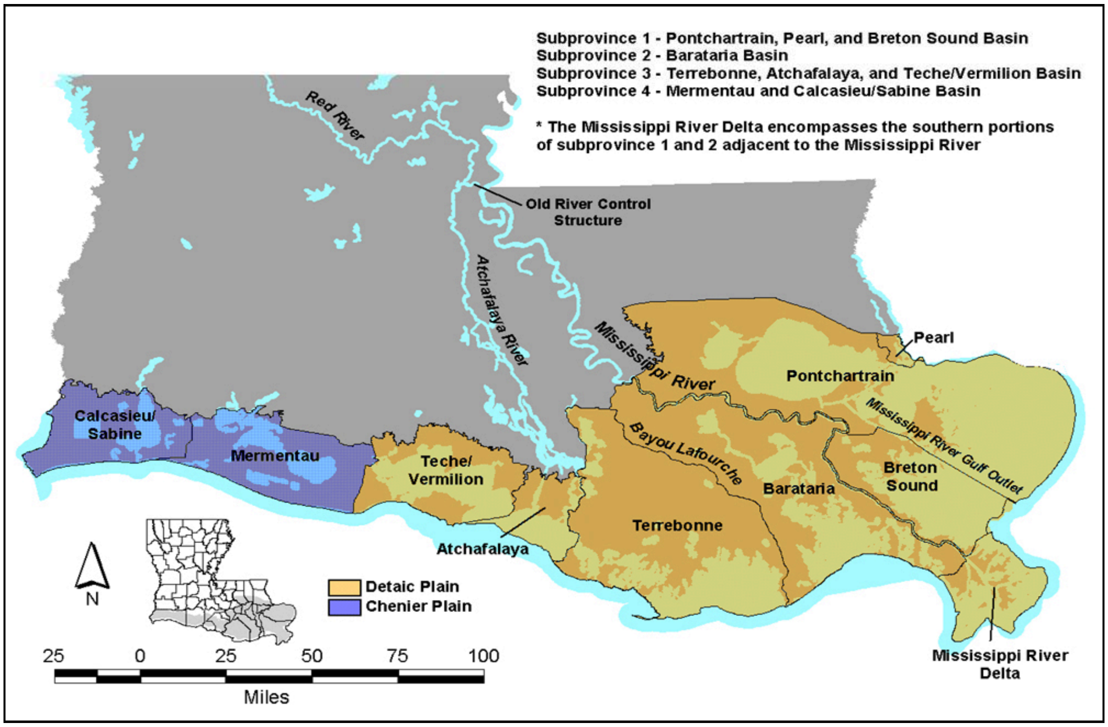

Figure MR2-2. Major Hydrologic Basins in the Louisiana Coastal Area.

2.2.1.1.1 *Deltaic Plain*

The Mississippi River Drainage Basin covers more than 1,245,000 square miles (3,224,553 square kilometers), and contains 41 percent of the contiguous United States and a portion of two Canadian provinces **(figure MR2-3)**. The Lower Mississippi Valley, which varies in width from 25 to 125 miles (40 to 201 kilometers), begins just below Cape Girardeau, Missouri and is roughly 600 miles in length. The Mississippi River has an annual average flow rate of 495,000 cubic feet per second (14,000 cms) and a freshwater discharge onto the continental shelf of 470,000,000 acre feet (580 cubic kilometers) per year. The river discharge into the Gulf of Mexico is distinctly seasonal, with highest flows occurring between March and May and lowest flows occurring during August and October.

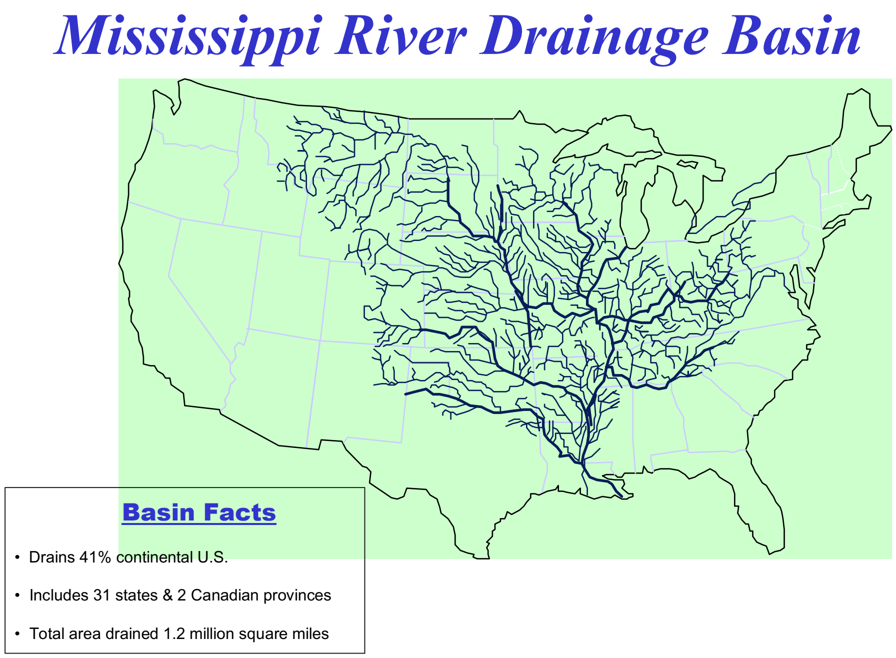

Figure MR2-3. Mississippi River Drainage Basin.

As described in section 1 INTRODUCTION, the Mississippi River and its distributaries historically provided immense volumes of land-building sediment and nutrients throughout Louisiana’s coastal areas. Levee activity along the Mississippi River in coastal Louisiana began as early as the 1700s. As the lower portions of the river were contained within the flood control levees, most of Louisiana’s coastal wetlands were deprived of the freshwater flows, sediment, and nutrients that had historically sustained them against natural factors of coastal land loss such as sea level change and subsidence.

By the early 1900s, human activities had a major influence on many of the key elements controlling the deltaic cycle. Flood protection levee systems completed in the early 1900s contained the flow of the Mississippi River, thereby reducing the number of overbank flooding events. Flood protection afforded to residents spurred a period of extensive development in the coastal area. Subsequent activities that altered the natural landscape and adversely impacted the natural hydrology included the dredging and maintenance of navigation and access canals, the construction of roads, levees, and oil and gas canals within wetlands, and drainage projects. As these and other activities impaired the deltaic cycle and disrupted the natural hydrology of the coastal ecosystems, extensive land building and sustenance of coastal wetlands diminished to the point where more land was being lost than was being created.

Today, Louisiana's Deltaic Plain is composed of two active deltas, the Mississippi River Delta, also known as the "birdfoot delta" (**figure MR2-4**), and the Wax Lake Outlet/Lower Atchafalaya River Delta. Delta formation is occurring in these two areas because of flood control management practices of the MR&T Project. Seventy percent of the combined flow of the Mississippi and Red Rivers at the latitude of the Old River Control Structure is diverted down the Mississippi River and into the northern Gulf of Mexico. The remaining 30 percent of the latitude flow is discharged into the gulf via the Atchafalaya Basin through Atchafalaya Bay, located to the west of the Mississippi River. These water flows provide sediment, freshwater, and nutrients that fuel land building and sustenance processes of the two active deltas.

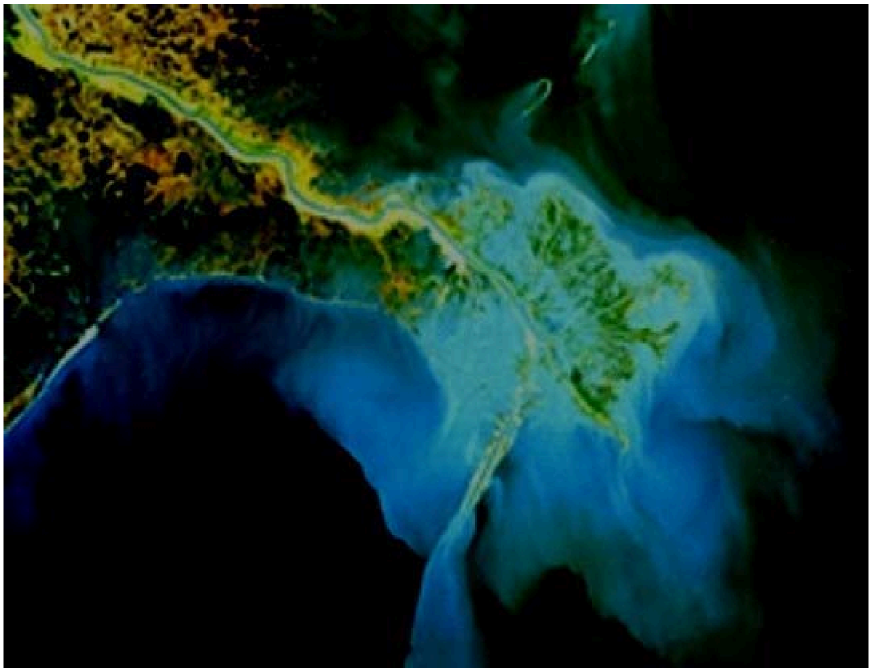

Figure MR2-4. Birdfoot Delta at the Mouth of the Mississippi River.

While the land-building phase of the deltaic cycle is occurring in the two active deltas, the remainder of the coastal area in the Deltaic Plain has transitioned into the abandonment phase. Some areas of the coast have been in the abandonment phase for hundreds of years, as evidenced by the presence of barrier headlands and islands, which are distinctive geomorphic features of the latter part of the degradation phase. Other areas of the Deltaic Plain, however, are being subjected to the natural processes that predominate in the abandonment phase (erosion, increased marine influences, habitat switching, and land loss) because they have been cut off from riverine influences (freshwater, sediment, and nutrients) by levees and other flood control projects. Many of these areas are located adjacent to the Mississippi River. The presence of navigation channels and oil and gas canals has also contributed to an increase in marine influences on coastal wetlands, which has facilitated their subsequent degradation and loss.

Bayou Lafourche provides an example of how the natural hydrology of a portion of the coastal area has been altered by natural and human factors. Bayou Lafourche, the geomorphic structure that separates Subprovince 2 from Subprovince 3, was formerly a main channel of the Mississippi River. By the 12th century, the river had switched course and initiated delta formation in another area of the Louisiana coastline. The remnant channel at Bayou Lafourche (now in a degrading portion of a delta lobe), in turn, reduced in size and flows to that of a minor distributary of the river. As discussed earlier, levee activity along the Mississippi River also occurred on river reaches at and near Bayou Lafourche. Review of Mississippi River Commission flow records indicates that by the mid to late 1800s, the bayou conveyed less than 2 percent of the Mississippi River during major flood flows. In 1904, a dam was placed across the distributary as a flood protection measure for Donaldsonville, Louisiana (Doyle 1972). While the dam fulfilled its authorized purpose to help prevent flooding in the city, its construction also severed what remained of the hydrologic connection between the Mississippi River and the wetlands in western Barataria Basin and eastern Terrebonne Basin. Today, these wetlands are experiencing the greatest, and most accelerated land loss as marine influences dominate the hydrology of the area. It is important to note that habitat degradation in the western Barataria Basin and eastern Terrebonne Basin would be occurring as a natural function of the degradation phase of the deltaic cycle. However, the virtual absence of riverine influence in these areas has accelerated the rate of degradation in the wetland habitats.

An important component of the hydrologic and deltaic process in the Deltaic Plain is the suspended sediment flowing down the Mississippi River. A combination of factors, such as dams, channel improvement features, and improved land use management practices upstream of the Louisiana coastal area, has decreased the available suspended sediment load within the system. While the retention of soil and reduction of bank erosion in the middle and upper portions of the Mississippi River Drainage Basin are considered as positive developments to people and industries upstream of Louisiana, the reduction of available sediment flowing down the Mississippi directly impacts the land-building and sustenance processes in the Deltaic Plain.

The following discussion describes the major hydrologic features in the various subprovinces of the Deltaic Plain, and identifies the more prominent water control and flood protection structures that affect the natural hydrology of each subprovince.

Subprovince 1

Subprovince 1 includes Breton Sound, Pontchartrain Basin, portions of the Pearl hydrologic basin, and the eastern portion of the lower Mississippi River Delta (**figure MR2-5**). The Pontchartrain Basin, the largest in the subprovince, is about 4,200 square miles (10,920 square kilometers) of estuarine habitat, and receives runoff from several smaller basins, including the Amite, Tickfaw, Tangipahoa, and Tchefuncte Basins. Lake Maurepas, Lake Pontchartrain, and Lake Borgne are the major lakes found in the basin. Pass Manchac connects Lake Maurepas with Lake Pontchartrain, while Chef Menteur Pass and the Rigolets connect Lake Pontchartrain with Lake Borgne and Mississippi Sound.

The Breton Sound Basin includes Lakes Lery and Big Mar, which are the largest water bodies in the northern part of the basin. Black Bay, California Bay, and Breton Sound are located in the southern part of the basin. Breton Sound is the largest water body in the subprovince. Currently, the Caernarvon Freshwater Diversion project introduces freshwater, sediment, and nutrients into the Lake Lery area of the upper Breton Sound marshes.

Major navigational channels include the MRGO, the GIWW, and the Mississippi River. The first two of these navigation channels introduce and/or compound marine influences in many of the coastal wetlands and water bodies within the subprovince.

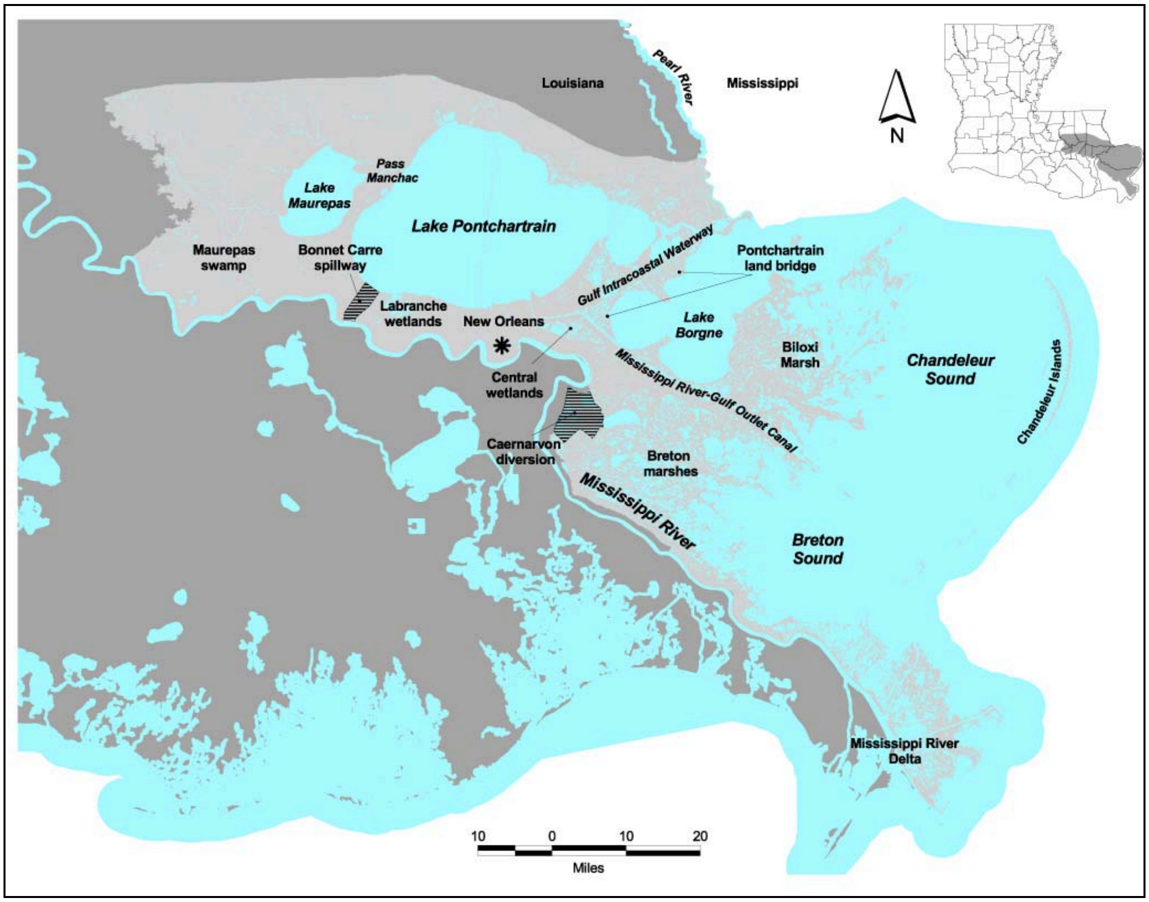

Figure MR2-5. Major Hydrologic Features of Subprovince 1.

Subprovince 2

Subprovince 2 is defined by the hydrologic boundary of the Barataria Basin, which is approximately 2,446 square miles (6,359 square kilometers), and the western portion of the lower Mississippi River Delta. The basin contains four major lakes; Lake Salvador, Lake Cataouatche, Little Lake, and Lac Des Allemands (**figure MR2-6**). The basin is separated from the gulf by a chain of barrier islands, which serve as a natural barrier to storm events and reduce marine influences on interior wetlands within the basin.

Currently, the Davis Pond Freshwater Diversion project directs Mississippi River water into the upper portion of the basin's wetlands. The primary purpose of the Davis Pond project has been to maintain salinity gradients in the central portion of the Barataria Basin. A majority of wetlands in the western portion of the basin are hydrologically isolated from riverine influences of the Mississippi River.

Major navigational channels in the subprovince include the Barataria Bay Waterway and the GIWW. Each of these navigation channels introduces and/or compounds marine influences in many of the interior coastal wetlands and water bodies within the subprovince.

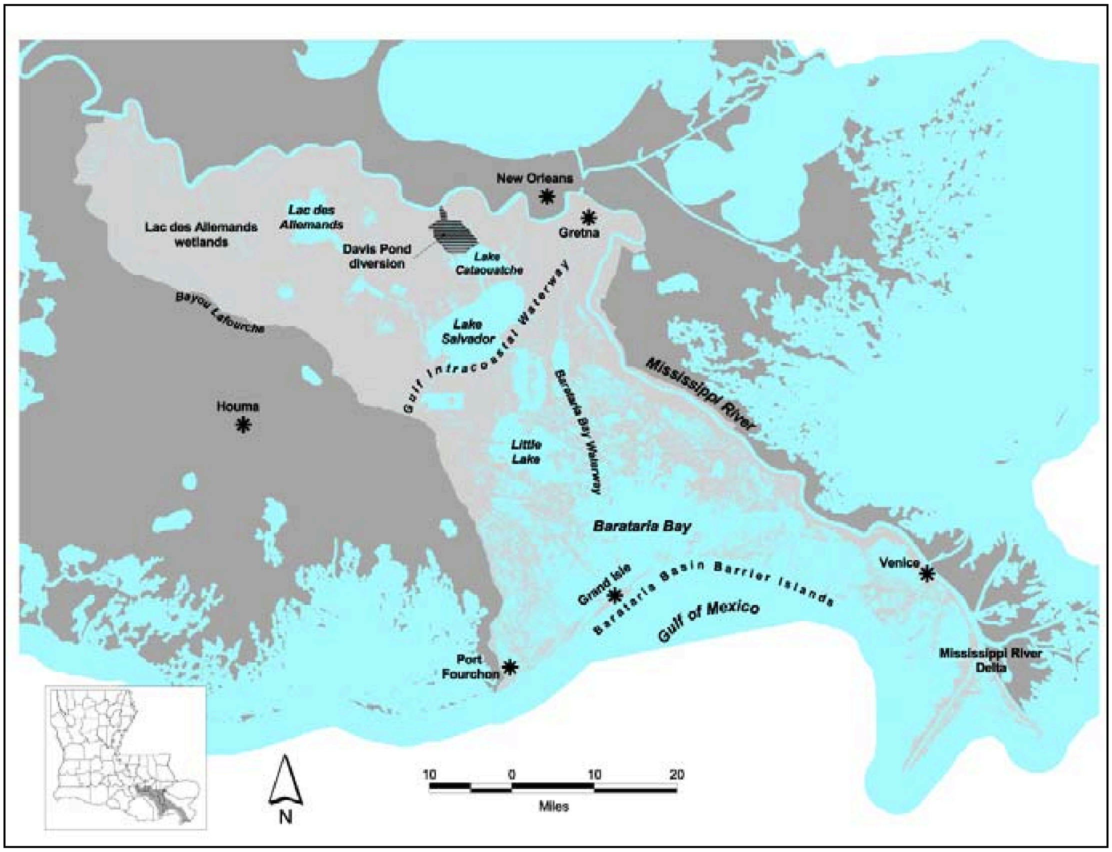

Figure MR2-6. Major Hydrologic Features of Subprovince 2.

Subprovince 3

Subprovince 3 consists of the Teche/Vermilion and Terrebonne Basins, and portions of the Atchafalaya Basin. The Teche/Vermilion Basin extends from Point Chevreuil to Freshwater Bayou Canal and includes East and West Cote Blanche Bays, Vermilion Bay, and the surrounding marshes (**figure MR2-7**). The Teche/Vermilion Basin has a drainage area of 3,040 square miles (7,904 square kilometers). The Atchafalaya Basin is part of the MR&T flood control system and has a drainage area of approximately 1,800 square miles (4,680 square kilometers). The Terrebonne Basin drainage area is approximately 1,455 square miles (3,783 square kilometers) in size.

The Atchafalaya River, a distributary of the Mississippi River, supports delta building and wetland creation at the Wax Lake Outlet and at the mouth of the Lower Atchafalaya River. In addition, the Lower Atchafalaya River nourishes the wetlands in the Teche/Vermilion Basin, located in the western portion of the subprovince. Wetland communities immediately adjacent to and west of the Lower Atchafalaya River are some of the healthiest wetlands in the Louisiana coastal area, fueled by the inputs of sediment and nutrients from the Atchafalaya River.

The wetland communities within the eastern portions of the Terrebonne Basin are hydrologically isolated. Wetlands in the southwestern portion of the Terrebonne Basin have some of the lowest loss rates in the state because they are nourished by the Atchafalaya River.

However, the wetland communities within the northwestern portion of Terrebonne Basin, including those located both north and south of the GIWW, have been, in part, separated from the influence of the Atchafalaya River. Instead, the hydrology of these areas is influenced by a widely variable pattern of Atchafalaya River backwater effect, rainfall runoff events, and marine processes.

It is important to note that a majority of the sediment and freshwater that supports the active deltas in the Lower Atchafalaya River Basin pass through the Upper Atchafalaya River Basin, which is not within the LCA Study area. In essence, the upper basin acts as a large conveyance system and reservoir for freshwater and sediment material that eventually fuels delta building at the Wax Lake Outlet and the mouth of the Lower Atchafalaya River. While delivery of sediment material is necessary to sustain and, if possible, augment land-building processes in the LCA Study area, the continued accumulation of sediment affects the hydrology of the upper basin, and adversely impacts its cypress tupelo swamps communities.

Barrier islands separating the coast from the gulf include the Timbalier and Isles Dernieres barrier systems. These systems provide protection to interior areas by reducing marine influences, such as wave action and saltwater intrusion.

Major navigation channels in the subprovince are the Atchafalaya River, Wax Lake Outlet, Houma Navigation Canal, GIWW, and Lower Atchafalaya River (south of Morgan City). Each of these navigation channels introduces and/or compounds marine influences in many of the interior coastal wetlands and water bodies within the subprovince.

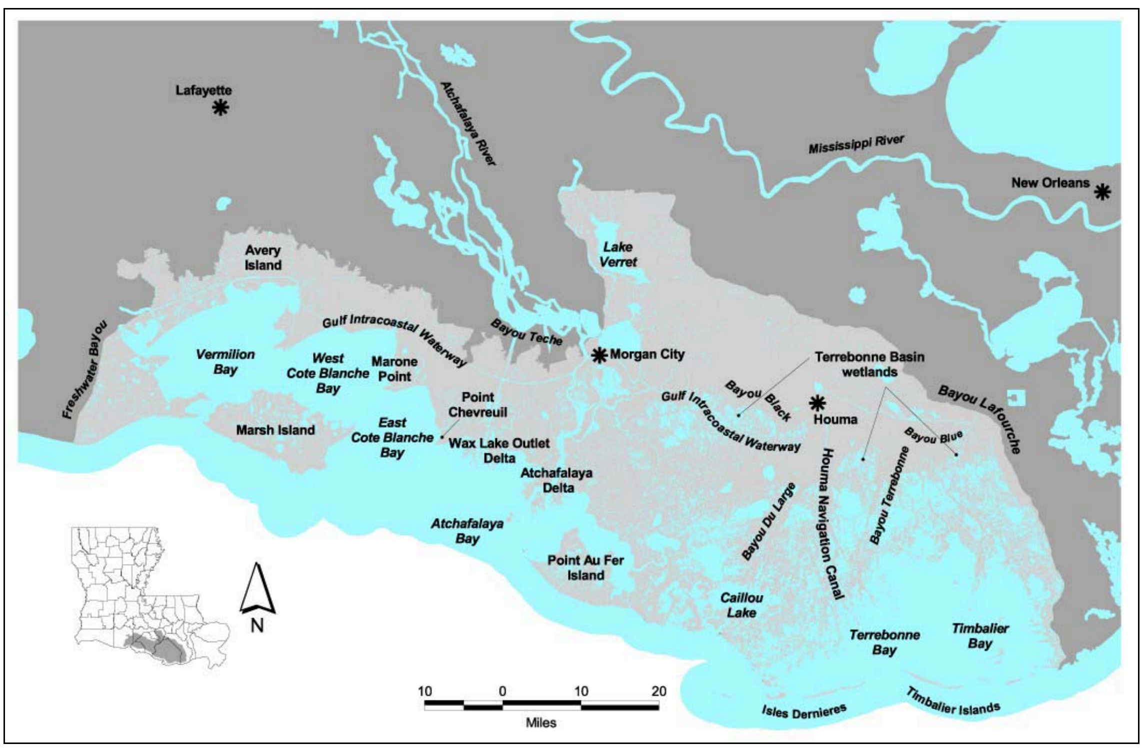

Figure MR2-7. Major Hydrologic Features of Subprovince 3.

2.2.1.1.2 *Chenier Plain*

Subprovince 4

In contrast to the Deltaic Plain, the Chenier Plain formed to the west of the Mississippi River, away from active deltaic growth. The Chenier Plain extends from Freshwater Bayou, Louisiana to Sabine Pass, Texas (**figure MR2-8**). As described in section 1 INTRODUCTION, Chenier Plain development is the result of the interplay of three coastal plain rivers, cycles of Mississippi River Delta development, and marine processes. Historically, cheniers acted as hydrologic barriers between the coastal salt marshes south of the cheniers and the inland fresh marshes and lakes to the north of the cheniers.

Two major hydrologic basins occur in the Chenier Plain, the Mermentau Basin and the Calcasieu/Sabine Basin. The Mermentau River is the primary freshwater supply for the Mermentau Basin, which has a drainage area of approximately 3,820 square miles (9,932 square kilometers). Hydrologic connectivity in some areas of the Chenier Plain, particularly within the Mermentau Basin, has been disrupted by several activities, including: the creation of dredge material banks from activities such as oil and gas canal dredging; the presence of east-west canals, such as the GIWW; and the operation of water control structures, such as the Calcasieu and Leland Bowman locks on the GIWW, the Freshwater Bayou Canal Lock, the Schooner Bayou Control Structure, and the Catfish Point Control Structure Grand Lake at the outlet for the Lower Mermentau River. These water control structures enable portions of the Mermentau Basin to be operated as a freshwater reservoir for agriculture, primarily rice and crawfish.

Other wetland communities have become "compartmentalized" and, in effect, hydrologically isolated through the creation of dredge material banks, roads and highways, and flood protection levees, all of which can restrict water flows into or out of the area. During extreme weather events, such as tropical storms, wetlands that are compartmentalized and/or subject to extremely slow drainage, can be particularly vulnerable to high precipitation levels, which can inundate wetlands with inches of water. In such cases, the typical result has been "ponding" of water over the wetlands. When properly managed, these may be important habitat for waterfowl. For example, the 16,000-acre (6478 ha) Pool of the Lacassine NWR and the 27,000-acre (10931 ha) Pool 3 on the Sabine NWR were created to maintain adequate freshwater habitat for migratory waterfowl. However, excessive ponding over an extended duration of time in certain types of wetland habitats can kill the vegetative communities and result in the eventual wetland loss (conversion to open water).

The Calcasieu/Sabine Basin is a shallow coastal wetland system with freshwater input at the north end, and a north-south circulation pattern through the Calcasieu and Sabine Lakes. Some east-west water movement occurs along the GIWW and interior marsh canals. In the Calcasieu drainage basin, the drainage area north of the point where the river crosses the GIWW is 3,235 square miles (8,411 square kilometers). The Calcasieu River flows through three small lakes before flowing into Calcasieu Lake near the coast. The Sabine drainage basin has a drainage area of 9,760 square miles (25,376 square kilometers). The headwaters start in northeastern Texas and the river runs about 150 miles (241 kilometers) before it meets the

Louisiana-Texas state line, then runs to the gulf. The Toledo Bend Reservoir and Sabine Lake are the major hydrologic features of the Sabine Basin.

The Sabine/Neches Waterway, Calcasieu River Navigation Channel, GIWW, Mermentau Ship Channel, and Freshwater Bayou Canal are navigational channels in the Chenier Plain that influence the hydrology within the subprovince, primarily by increasing marine influences (saltwater intrusion, wave energies) into freshwater and other interior marshes.

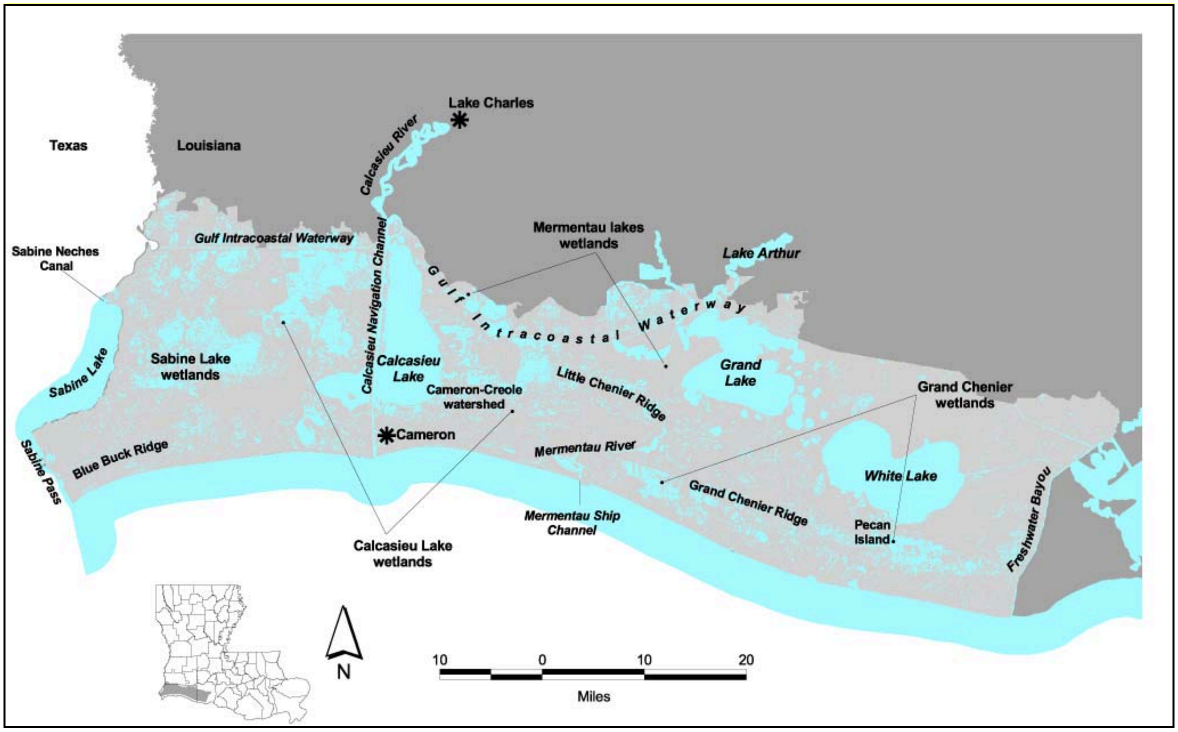

Figure MR2-8. Major Hydrologic Features of Subprovince 4.

2.2.1.2 <u>Future without-project conditions</u>

The following future without-project conditions assume no further restoration actions beyond the presently planned/approved construction or maintenance actions in the study area, including those contained in the CWPPRA and other programs described in section 1 INTRODUCTION.

Without action, riverine influences (e.g. freshwater, sediment, and nutrients) would continue to sustain land-building processes at the Mississippi River Delta and the Wax Lake Outlet/Lower Atchafalaya River Delta. In addition, wetland communities adjacent to and immediately to the west southeast of the Atchafalaya River would continue to be nourished and sustained by the river.

For much of the remaining Louisiana coastal area, however, marine processes would continue to increasingly dominate the hydrology of wetland communities. The projected loss of an additional 328,000 acres (132,794 ha) of coastal wetlands by 2050, including the degradation and loss of barrier islands and gulf shorelines, would exacerbate the problems of saltwater intrusion and erosion, especially during tropical storm events. Based on a USACE hurricane study for Morgan City and vicinity, a drop in storm surge of approximately 1 foot (0.3 meters) was observed for every 3 miles (4.8 kilometers) inland (USACE 1963). As the marshes continue to fragment and disappear, in the future, storm surges would travel farther inland and inundate interior wetlands with saline, gulf waters.

In addition, existing and newly constructed oil and gas canals and maintenance of navigation channels would continue to facilitate saltwater intrusion into interior coastal wetlands. Salinity gradients across the coast would migrate north and become more narrow and variable without additional inputs of freshwater from riverine sources to hold back gulf waters.

2.2.1.2.1 *Deltaic Plain*

A majority of the wetland communities in the Deltaic Plain would remain isolated from riverine influences. The most notable exceptions in Subprovinces 1 and 2 would be those wetlands nourished by the Davis Pond and Caernarvon Freshwater Diversion Projects. In these areas, salinity gradients would be maintained and the freshwater, sediment, and nutrients introduced through the diversions would continue to aid land-preservation processes. In Subprovince 3, those wetlands located immediately adjacent and to the west of the Lower Atchafalaya River would also receive enough river water to maintain salinity gradients and sustain land-building processes.

For other areas in the Deltaic Plain, including western Barataria Basin, eastern Terrebonne Basin, and areas adjacent to the Mississippi River, marine influences would continue to predominate in the future. Wetland communities in these areas, isolated from riverine influences, would succumb to a combination of natural factors that cause land loss such as sea level change, erosion from tidal processes (e.g. wave action), and subsidence.

2.2.1.2.2 *Chenier Plain*

Marine influences would continue to affect the hydrology of interior areas through navigation channels and through breaches of eroded gulf shorelines. The absence of additional salinity controls in the Calcasieu/Sabine Basin would allow continued saltwater intrusion within coastal wetland communities. In the Mermentau Basin, existing water management practices and infrastructure, such as the east/west Highway 82, would result in future ponding of water within coastal marshes.

2.2.2 Coastal Habitats and Productivity

2.2.2.1 <u>Existing conditions</u>

In addition to the Mississippi and Atchafalaya Rivers, the most prominent natural features in the Deltaic Plain are the abandoned Mississippi River courses and the ridges and levees that bordered them, large shallow lakes, extensive marshes, large bays, bayous, barrier headlands, and barrier islands. Natural levee ridges are now separated by vast expanses of freshwater, intermediate, brackish, and saline marshes, as well as by swamps, flotant marsh, maritime forests, salt domes, and tidal channels. Each of these coastal habitats contributes to the extensive diversity of the coastal ecosystem and is essential to its stability. Detailed descriptions of each of these habitat types are contained in the FPEIS.

As described in section 1 INTRODUCTION, the oscillating nature of the deltaic process drove spatial and distribution patterns of coastal ecosystems back and forth between ones dominated by riverine and marine influences. Accordingly, the hydrology in the coastal ecosystems, particularly in the Deltaic Plain, greatly influenced the types and productivity of vegetative communities. During the delta advancement phase, major inputs of freshwater led to the predominance of riverine influence over marine influence, and, as a result, the majority of coastal marsh in the growing delta was cypress/tupelo swamp and freshwater marsh. This scenario reflects the coastal habitat conditions in the two active deltas within the study area, the Mississippi River Delta and the Atchafalaya Delta.

During the abandonment of a delta, freshwater inputs decline and allow marine influences to predominate over riverine influence in coastal areas nearby and adjacent to the gulf. As marine influences take hold and salinity levels rise, distinct zones of coastal habitats develop with increasing distance inland from the coast, beginning with saline marshes, and transitioning into brackish, intermediate, and finally to freshwater marsh and swamp. It is during this time that vegetation community diversity, as well as plant and animal productivity (e.g. primary and secondary productivity), are at their highest. As a delta continues to degrade, subsidence and storms cause the conversion of low-lying vegetated areas to open water and the redistribution of marine sediment. These actions eventually lead to conditions that expedite interior marsh loss. As interior marshes disappear, and as marine influences and storms interact with the abandoned delta, the resulting geomorphic structures, or remnants of the delta, are the barrier headland, and eventually, the barrier islands. This scenario reflects the coastal habitat conditions in much of the remaining Deltaic Plain.

Approximately 80 percent of the Mississippi River Deltaic Plain is in some phase of abandonment because of loss of riverine influences, and much of the area is in advanced stages of wetland deterioration (U.S. Geological Survey [USGS]-National Wetlands Research Center [NWRC] 2004).

2.2.2.1.1 *Deltaic & Chenier Plains*

The Deltaic Plain is a vast wetland area characterized by large lakes and bays, natural levee ridges, and bottomland hardwood forests that gradually decrease in elevation to various wetland marshes. Numerous barrier islands and headlands are also present. The Chenier Plain is characterized by large lakes, wetlands, cheniers, and coastal beaches. Large freshwater basins occur on the landward side of the natural ridges and a zone of brackish to saline marshes occurs on the seaward side.

Because of the complexity and diversity of coastal habitats within the Deltaic and Chenier Plains, subdivision of the plains provides a subprovince level perspective of the vegetative communities. Therefore, the following discussion focuses on existing coastal habitats within each of the four previously described subprovinces.

Recent GIS analysis and classification by USGS-NWRC for the LCA Study provided a summary of coastal habitat types by subprovince. This information is provided in **table MR2-1**.

Table MR2-1. Existing Habitat and Vegetation.

	Existing Conditions[1] (Acres)			
	Subprovince 1	**Subprovince 2**	**Subprovince 3**	**Subprovince 4**
Wetland Forest/Swamp	293,100	236,100	358,300	10,500
Wetland Scrub[2]	26,800	16,000	48,000	16,900
Freshwater Marsh	70,700	161,400	290,500	338,000
Intermediate Marsh	136,400	76,800	167,700	278,000
Brackish Marsh	154,000	63,600	194,700	135,300
Saline Marsh	126,500	123,200	140,900	32,800
Open Water	2,192,700	714,700	1,199,300	410,900
Total Marsh/Wetland[3]	807,500	677,100	1,200,100	811,500
Upland (Other)[4]	42,400	33,600	59,500	106,800

[1]Existing conditions taken as of year 2000, data provided by USGS for LCA Study.
[2]Wetland scrub was not evaluated separately, but acreage is included with associated primary wetland types.
[3]Total wetland acres does not include upland or open water acres.
[4]Uplands (Other) category includes all other areas, including upland agricultural areas and urbanized areas.

2.2.2.1.2 *Quantification of coastal land loss*

Across much of the Louisiana coast, wetland loss and shoreline erosion continue largely unabated, resulting in accelerated coastal land loss and ecosystem degradation. Over time, the rates of Louisiana's coastal land loss have varied. For example, the conversion of numerous large areas (greater than 40 acres [16.1 ha]) of interior marsh to open water, prevalent between 1956 and 1978, continued to occur, to a lesser extent, from 1978 to 1990 and further decreased between 1990 and 2000 (**table MR2-2**). Continued shoreline erosion and conversion of interior marsh habitat to open water (ponds) are the primary loss patterns dominating the last decade. Interior ponds range in size from 2.5 to5.0 acres (1 or 2 ha) to 125 acres (50 ha), with the majority of ponds occurring within the coastal fresh to intermediate marshes. Detectable shoreline erosion in larger lakes, bays, and ponds ranged from 165 to 1,000 feet (50 to 300 m).

Table MR2-2. Net Loss Trends by Subprovince.

	1978-1990 Net loss Mi^{2}*	1990 - 2000 Net Loss Mi^2	1978 – 2000 Net Land Loss Mi^2	Net Loss 22 Years Mi^2/Year	% Total Loss from 1978 to 2000 by Area
Subprovince 1	52	48	100	4.5	15%
Subprovince 2	148	65	213	9.7	32%
Subprovince 3	134	72	206	9.4	31%
Subprovince 4	85	54	139	6.3	21%
Total	419	239	658	29.9	100%

*1978-1990 Net loss figures were based on Barras et al. (1994). The 1978 to 1990 basin level and coast wide trends used in this study were aggregated to reflect LCA subprovinces for comparison with the 1990-2000 data. The basin boundaries used in Barras et al. (1994) were based on older CWPPRA planning boundaries and are not directly comparable to the LCA boundary used to summarize the 1990 to 2000 trend data. The 1990 to 2000 net loss figures include actively managed lands for comparison purposes with the 1978 to 1990 data.

Subprovince 1

Subprovince 1 contains great habitat diversity, including extensive bottomland hardwood forests adjacent to the Mississippi River and barrier islands bordering the Chandeleur Sound. Cypress-tupelo swamp is the dominant ecosystem type in the upper portion of the subprovince. South of the swamps, marshes extend to the Gulf of Mexico and the Mississippi Delta. Freshwater marshes are found in the north, with a band of intermediate marsh lying southward. Portions of the basins contain brackish marshes, and saline marshes fringe the gulf and Breton Sound. Approximately 73 percent of the coastal habitat in Subprovince 1 is open water. Freshwater habitats dominate the basin, comprising approximately 48 percent. The remaining coastal habitat is fairly evenly distributed between intermediate, brackish, and saline marsh.

Subprovince 2

Subprovince 2 contains great habitat diversity, including extensive bottomland hardwood forests adjacent to the Mississippi River and Bayou Lafourche. Cypress-tupelo swamps cover the upper Barataria Basin. South of the swamps, marshes extend to the gulf in the Mississippi Delta and lower Barataria Basin. Portions of the basin contain brackish and saline marshes that fringe the Gulf of Mexico. The southern end of the Barataria Basin is bounded by a series of barrier headlands, islands, and shorelines. In Subprovince 2, approximately 53 percent of the coastal habitat is open water. Of the remaining habitat, about 61 percent consists of freshwater habitat types. Saline marsh is slightly more abundant than intermediate or brackish marsh.

Subprovince 3

Subprovince 3 contains barrier islands, forested wetlands, coastal marshes, and large lakes. Portions of the subprovince, including the Penchant Basin, also contain large areas of fresh floating marsh (flotant). About 50 percent of the coastal habitat in Subprovince 3 is open water. Wetland forest/swamp is the second most abundant habitat type. Freshwater habitats account for approximately 58 percent of the coastal habitat, excluding open water. The remainder is evenly distributed between intermediate, brackish, and saline marsh.

Subprovince 4

Subprovince 4 consists of open water ponds and lakes, cheniers, gulf shorelines, and freshwater, intermediate, and saline marsh. Over time, many of the freshwater marshes have been impounded, inundated, and converted to open water ponds or impounded, drained, and converted to more saline marsh. Nevertheless, freshwater habitats, dominated by freshwater marsh, still account for the majority (45 percent) of coastal habitat. Approximately 37 percent of the coastal habitat is open water. Intermediate marsh dominates the remaining habitat, followed by brackish marsh, and then saline marsh.

Barrier Island Systems

Barrier island systems, composed primarily of barrier shorelines (beaches), headlands, and islands, are the remnant geomorphic structures in the latter phases of deltaic abandonment.

They are located principally in the Deltaic Plain and include the Chandeleur, Plaquemines, Bayou Lafourche, and Isles Dernieres barrier systems.

The Chandeleur Island system is the oldest barrier island arc on the Deltaic Plain. These islands enclose Breton Sound and Chandeleur Sound. The Breton Island National Wildlife Refuge (NWR) is included in this system. It is the second oldest NWR in the country and is managed by the USFWS on behalf of the public. The Plaquemines barrier island system forms the seaward geologic framework for the eastern Barataria Basin and consists of remnant barrier spits and islands defined either by a tidal pass, or the entrance to a bayou. The Bayou Lafourche barrier island system forms the seaward geologic framework of the western Barataria Basin and the eastern Terrebonne Basin. This barrier island system consists of the only human and commercially developed barrier island in Louisiana: Grand Isle. The Isles Dernieres barrier island system forms the seaward geologic framework for the western Terrebonne Basin. Although this barrier island system was a continuous shoreline system in 1853, today it consists of five main islands. Detailed descriptions of Louisiana's barrier island systems, including land loss comparisons over the past 100 years, are provided in Williams, Penland, and Sallenger (1992) "Atlas of Shoreline Changes in Louisiana from 1853 to 1989" and in appendix D LOUISIANA GULF SHORELINE RESTORATION REPORT.

Barrier island systems provide protection to the wetlands, bays, and estuaries behind them and help reduce wave energy at the margins of coastal wetlands, thereby limiting erosion (Williams, Penland, and Sallenger 1992) and tropical storm impacts. As such, barrier island systems are key geomorphic structures that help sustain other coastal habitats, particularly the interior coastal marshes and swamps, by reducing marine influences and tropical storm impacts. These structures also serve as essential habitat for many terrestrial and aquatic species, including those listed by USFWS as threatened or endangered.

Another component of barrier island systems is the offshore sand shoals and nearshore sand deposits. These features developed as part of the deltaic process that eroded and submerged barrier headlands and barrier islands. Because of the large volumes of sand associated with these features, they are often mined for industry or for coastal restoration purposes. Four major sand shoals occur along the Louisiana coastline. These shoals are Trinity Shoal, Outer Shoal, St. Bernard Shoals, and Ship Shoal. Although the offshore and nearshore features are no longer as efficient in providing shoreline protection as the headlands or barrier islands, they do provide some buffering effect from wave action.

Louisiana’s barrier island systems are experiencing some of the highest land loss rates in the Nation, particularly the Plaquemines, Bayou Lafourche, and Isles Dernieres systems. While the deterioration of barrier island systems is a natural feature of the deltaic cycle, historically their loss was offset with the creation of a system in another portion of the Deltaic Plain, a function of river switching and the subsequent delta abandonment phase. Today, there is not another barrier island system "waiting in the wings" to replace those that are being lost.

Several portions of the gulf shoreline in the Chenier Plain are also experiencing severe rates of land loss as a result of erosion from marine influences and storm events. Rates of loss in some areas exceed 35 to 40 feet per year (10.6 to 12.1 meters per year). The gulf shorelines in the Chenier Plain provide similar protection to interior coastal habitats as that provided by barrier islands, by reducing marine influences and tropical storm impacts.

2.2.2.2 Future without-project conditions

The following future without-project conditions assume no further actions beyond the presently planned/approved construction or maintenance actions in the study area, including those contained in the CWPPRA and other flood control, navigation, and restoration programs described in section 1 INTRODUCTION.

2.2.2.2.1 *Deltaic & Chenier Plains*

Without action, marine influences and other natural and human factors, such as subsidence, sea level change, navigation channels, and oil and gas canals would result in continued coastal habitat loss in both the Deltaic and Chenier Plains. Land building would continue in the Deltaic Plain at the two active deltas, as well as in areas influenced by CWPPRA projects and the Davis Pond and Caernarvon Freshwater Diversion Projects. Coastal habitats in these areas of land creation would primarily be freshwater marsh, a result of the riverine influence that formed them. Other areas in the Deltaic and Chenier Plains would experience habitat switching from freshwater marsh and bottomland hardwood forest, including cypress/tupelo swamp, to intermediate, brackish, and saline marshes as salinity regimes adjust with increased saltwater intrusion and marine influence.

Louisiana coastal wetlands have been subjected to high rates of relative sea level change (rise) for centuries in part due to high subsidence rates associated with the compaction and dewatering of deltaic sediment. Some Louisiana marshes have adjusted to these high rates, and still survive in areas where measured rates from tide gauges are over 1 cm per year, and others are experiencing stress which may in part be driven by the relative sea level change. In Louisiana it is well documented that high water events associated with frontal passages and tropical storms and hurricanes deliver most of the sediment that is currently deposited in coastal marshes (Reed 1989; Cahoon et al. 1995), while some freshwater areas will still be able to maintain elevation through underground vegetative growth (Nyman and DeLaune 1991). These factors undoubtedly contribute to sustainability of existing Louisiana marshes and it is not known how marshes will accommodate future increases in relative sea level.

Despite a future increase of habitat switching of low salinity coastal habitats (e.g. freshwater marsh, cypress/tupelo swamp, intermediate swamp) to those that survive under more saline conditions (e.g. brackish and saline marshes), the accelerated rate of land loss across the coast and the narrowing of zones based on differing salinity regimes would result in significant reductions of the brackish and saline marshes under a future without-project condition (**table MR2-3**). Land loss, saltwater intrusion, and marine influences, conditions that would be exacerbated with the loss of the barrier island systems, would result in the narrowing of the broadly delineated zones of coastal habitat types that exist today. As the zones narrow into smaller bands of coastal habitat types, the acreage associated with each coastal habitat type, particularly brackish marsh and saline marsh, would also diminish.

In **table MR2-3**, the percent acreage of each habitat type for existing (Year 0) and future without-project (no action at Year 50) conditions is displayed. In addition, for each subprovince, graphs depict the change in habitat acreage and vegetative productivity for Year 0, 10, 20, 30, 40, and 50, assuming there is no additional action (**figures MR2-10** to **MR2-13**). It is important to note that the significant increases of freshwater marsh in Subprovinces 1 and 2 largely represent the effects from ongoing restoration projects, such as the Davis Pond and Caernarvon Freshwater Diversion projects, especially the running of Davis Pond at an average of 5,000 cfs. The substantial increase in intermediate marsh within Subprovince 3 is likely due to the averaging of salinities across large, predominantly fresh marsh tracts in the salinity/habitat forecasting methodology. Further refinements to habitat distribution methodology may be undertaken to improve forecasting. Finally, **figures MR2-10** to **MR2-13** illustrate that decreases in plant productivity across the entire coast are a function of land loss and mirror the continued trend of coastal land loss throughout the study area (see appendix C HYDRODYNAMIC AND ECOLOGICAL MODELING for more information on plant productivity modeling and calculations).

Table MR2-3. Percent Habitat Composition. *With the Future Without-Project Conditions at Year 0 and Year 50 By Subprovince.*

	Percent Composition						
	Fresh Marsh	Intermediate Marsh	Brackish Marsh	Saline Marsh	Swamp	Water	Upland[1]
Subprovince 1							
No Action Year 0	2.0	4.4	5.0	3.1	9.7	61.8	14.0
No Action Year 50	5.7	2.7	3.9	1.5	9.0	63.2	14.0
Percent Change	185.0	-38.6	-22.0	-51.6	-7.2	2.3	0.0
Subprovince 2							
No Action Year 0	10.1	4.8	3.6	6.6	16.4	40.4	18.1
No Action Year 50	14.2	2.9	0.0	0.0	15.9	48.9	18.1
Percent Change	40.6	-39.6	-100.0	-100.0	-3.0	21.0	0.0
Subprovince 3							
No Action Year 0	12.6	7.1	7.4	4.2	14.3	44.4	10.0
No Action Year 50	1.2	22.8	1.5	0.2	12.4	51.9	10.0
Percent Change	-90.5	221.1	-79.7	-95.2	-13.3	16.9	0.0
Subprovince 4							
No Action Year 0	25.4	20.8	10.1	2.2	0.3	29.8	11.5
No Action Year 50	22.9	17.4	14.8	0.0	0.2	33.2	11.5
Percent Change	-9.8	-16.3	46.5	-100.0	-33.3	11.4	0.0

[1]*Approximate percent composition is provided for upland habitat, but uplands were not assessed in the coastal land loss modeling effort, as described in appendix B HISTORIC AND PROJECTED COASTAL LOUISIANA LAND CHANGES: 1978-2050 USGS LAND LOSS.*
Note: The "Percent Change" represents the change for each specific habitat class in each subprovince from Year 0 to Year 50 with no action. Future without-project conditions were generated from the ecological modeling efforts described in appendix C HYDRODYNAMIC AND ECOLOGICAL MODELING.

2.2.2.2.2 *Quantification of future land loss*

According to the latest USGS information (see appendix B HISTORIC AND PROJECTED COASTAL LOUISIANA LAND CHANGES: 1978-2050), the projected 2000-2050 land changes are a future land loss of 674 square miles (1,746 square kilometers) and a future land gain of 161 square miles (417 square kilometers). These gains were from the following sources: CWPPRA projects, 54 square miles (140 square kilometers); Caernarvon diversion, 25 square miles (65 square kilometers); Davis Pond diversion, 53 square miles (137 square kilometers); Atchafalaya Delta building, 14 square miles (36 square kilometers); and Mississippi River Delta building, 15 square miles (39 square kilometers). Land gains for Davis Pond and Caernarvon diversion reflect new land created and land projected to be saved from loss by the project's operations over the next 50 years. Thus, the projected net land loss is 513 square miles (1,329 square kilometers) (**table MR2-4**). Estimates of land loss from 1956 to 2050 project gross loss (without projected gain) at 2,199 square miles (5,695 square kilometers) and net loss (with projected gains) at 2,038 square miles (5,278 square kilometers) over this 94-year period. Patterns of past and predicted land loss and gain are illustrated in **figure MR2-9**.

Table MR2-4. Projected Net Land Loss Trends by Subprovince from 2000 to 2050.

	Land in 2000 Mi^2	Projected Land in 2050 Mi^2	Net Land Loss Mi^2	% Land loss between 2050 and 2000	Land Loss Mi^2/yr	% Total loss by area
Subprovince 1	1,331	1,270	61	4.61%	1.26	12%
Subprovince 2	1,114	928	186	16.68%	3.58	36%
Subprovince 3	1,975	1,746	229	11.59%	4.44	45%
Subprovince 4	1,431	1,394	37	2.59%	0.72	7%
Total Mi^2	5,851	5,338	513	8.77%	10.00	100%
Km^2	15,154	13,825	1,329		25.90	

Note that total percentage of land loss is the percentage of total net land loss (513 square miles) in 2050 to the existing land (5,851 square miles) in 2000.

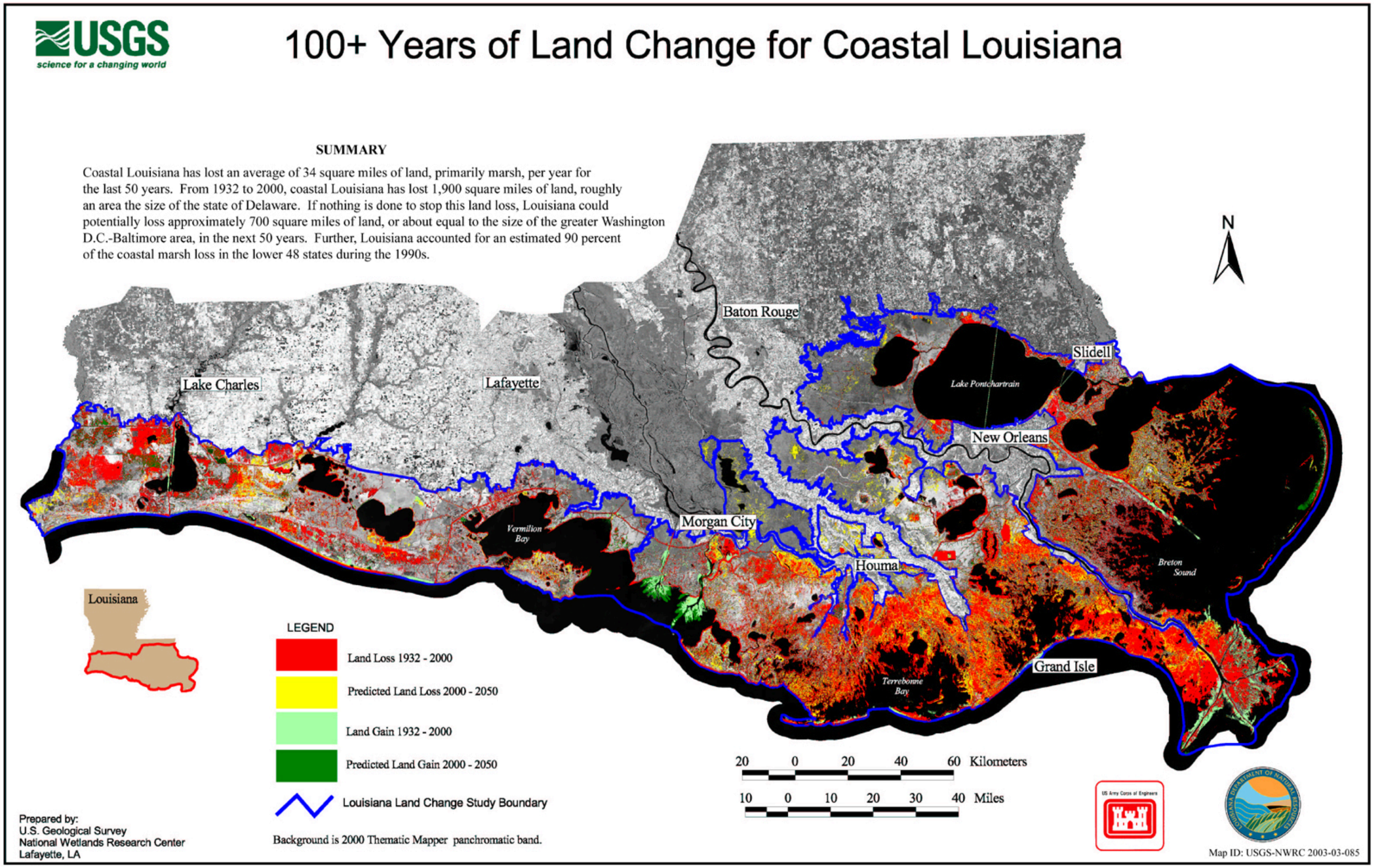

Figure MR2-9. Past and Projected Land Changes from 1932-2050.

Subprovince 1

In Subprovince 1, saline marsh, brackish marsh, and intermediate marsh areas are all expected to decrease in percentage, while freshwater marsh, swamp, and open water areas are expected to increase by 2050. The increase in water area percentage lessens habitat diversity and is indicative of a net land loss. Overall, habitat is expected to change to a fresher marsh condition. The habitat distribution is expected to continue to reflect a salinity gradient that is predominantly fresh. Land acreage would continue to decrease through Year 50, while plant productivity would initially increase through Year 10, and then decrease through Year 50 (**figure MR2-10**).

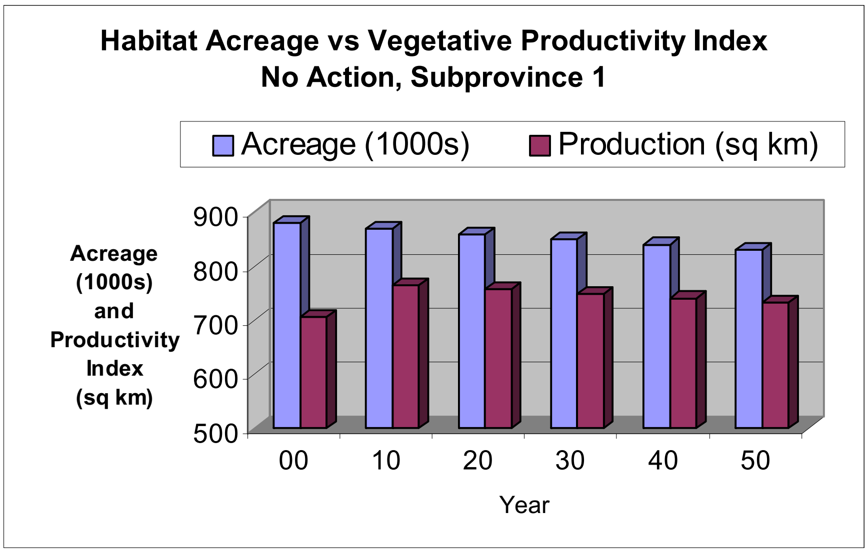

Figure MR2-10. Habitat Acreage and Vegetative Productivity for Subprovince 1 under Future Without-Project Conditions.

Without action, the Maurepas Swamp, which contains extensive cypress swamps, would continue to deteriorate as a result of subsidence, a lack of freshwater circulation, and a lack of riverine influence. Under these conditions, many of the cypress stands would continue to be starved for land building sediment and nutrients, which would prevent regrowth and prevent them from keeping pace with subsidence.

The Central Wetlands, located near the land bridge that separates Lakes Pontchartrain and Borgne, are composed of intermediate and brackish marshes. Without action, intermediate and brackish marshes would continue to be stressed by subsidence and a lack of riverine influence (e.g., freshwater, sediment, and nutrients). In addition, these wetland communities would continue to experience deterioration and loss due to erosion from wave energies in Lake Borgne.

Saltwater intrusion from navigation channels and oil and gas canals would continue to result in the loss of freshwater marshes and accelerated habitat switching from freshwater marshes to intermediate and brackish marshes in the Biloxi Marshes, the Central Wetlands, and the Golden Triangle Wetlands. Farther south and southeast, the intermediate and brackish marshes of Breton Sound would continue to experience deterioration and loss due to subsidence, a lack of freshwater circulation, and a lack of new sediment and nutrients.

Subprovince 2

In Subprovince 2, the percent of acreage in swamp, intermediate marsh, brackish marsh, and saline marsh areas are all expected to decrease while fresh marsh and open water areas are expected to increase by 2050. The increase in open water area indicates a reduction in habitat diversity and a net land loss. Virtually all of the brackish and saline marshes along the central and southern edges of Subprovince 2 would be lost by 2050. The remaining marsh habitat would be freshwater marsh and wetland forest habitats, with some intermediate marsh interspersed within them. A narrow band of brackish marsh habitat is likely to occur along the coastal shoreline. Land acreage would continue to decrease through Year 50, while plant productivity would initially increase through Year 10, and then decrease through Year 50 (**figure MR2-11**).

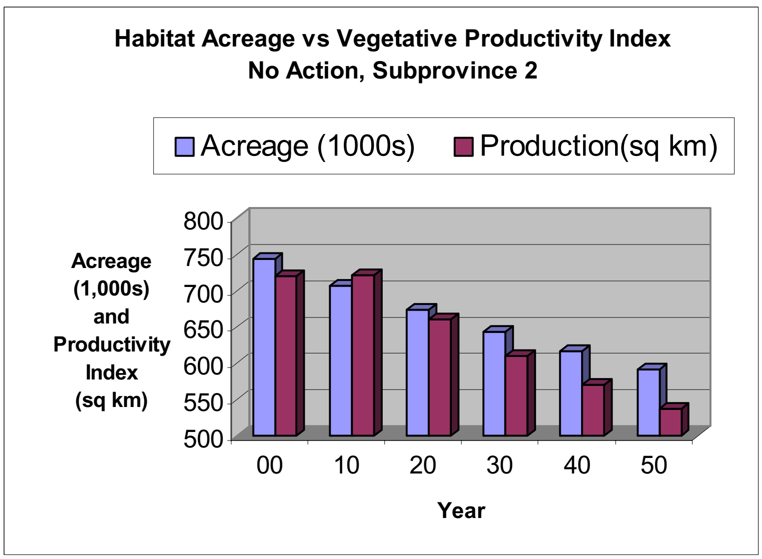

Figure MR2-11. Habitat Acreage and Vegetative Productivity for Subprovince 2 under Future Without-Project Conditions.

Without action, the wetlands surrounding Lac Des Allemands, primarily composed of forested wetlands, would continue to experience severe deterioration and swamp loss due to subsidence, a lack of freshwater circulation, and a lack of riverine influence. Similar to the cypress stands within the Maurepas Swamp in Subprovince 1, the swamps surrounding Lac Des Allemands would continue to be starved for land building sediment and nutrients, which would prevent re-growth and prohibit them from keeping pace with subsidence.

The wetlands in the upper Barataria Basin would continue to deteriorate due to subsidence, saltwater intrusion, and a lack of riverine influence (e.g., freshwater, sediment, and nutrients), while the middle and lower Barataria Basin wetlands would continue to experience severe deterioration and loss due to subsidence, a lack of riverine influence, and increased tidal influences, which would be exacerbated by oil and gas canals and the loss of the barrier island systems. Wetland communities in the west and southwest area of the basin, primarily brackish and saline marshes, would experience the greatest degree of habitat loss because the area is so far removed from the Mississippi River.

Subprovince 3

In Subprovince 3, the percent of acreage in swamp, freshwater marsh, brackish marsh, and saline marsh areas are all expected to decrease while intermediate marsh and open water areas are expected to increase by 2050. The increase in water area percentage indicates a net land loss and loss of habitat diversity. Salinity modeling in the forecasting model shows that a large portion of existing emergent wetland habitat would be converted to open water and more than half of the remaining emergent wetland habitat would likely be converted to intermediate marsh. Land acreage would decrease (**figure MR2-12**).

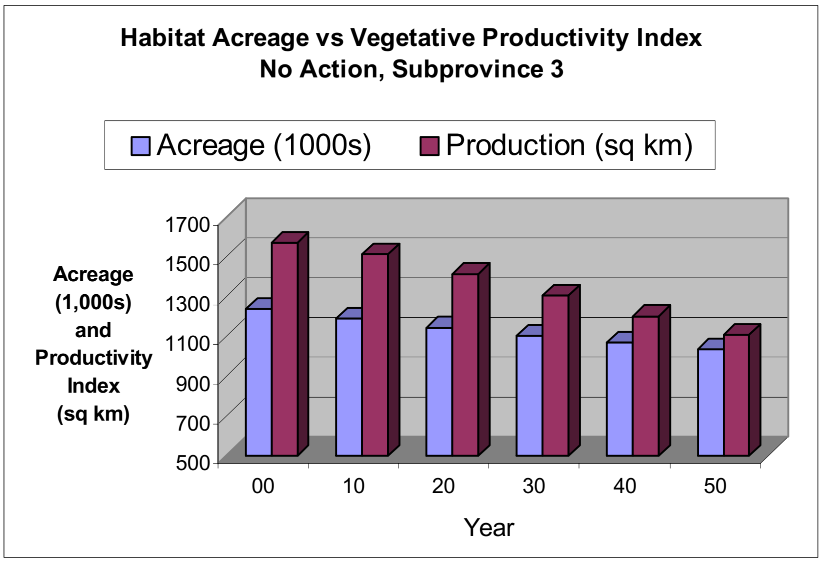

Figure MR2-12. Habitat Acreage and Vegetative Productivity for Subprovince 3 under Future Without-Project Conditions.

Without action, the freshwater, intermediate, and brackish marshes in the northern and eastern areas of Terrebonne Basin would continue to deteriorate and disappear due to the combined effects of subsidence, saltwater intrusion, and a lack of riverine influence. The flotant marshes within the Penchant Basin, located in northwest Terrebonne Basin, would continue to deteriorate due to excessive backwater flooding events from the Atchafalaya River. To the south, the brackish marshes surrounding Lake Mechant would continue to deteriorate due to saltwater intrusion and a lack of riverine influence.

Wetland communities in East Cote Blanche Bay would continue to deteriorate and erode due to increased marine influences, such as wave action. Without action, the intermediate and brackish marshes on Point Au Fer Island would likely deteriorate and be lost as saltwater intrusion and marine influences move through breaches of the gulf shoreline of the island, despite the restoration projects under CWPPRA designed to stabilize portions of the shoreline. These wetland communities are currently sustained by riverine influences from the Atchafalaya River.

Without action, the saline marshes surrounding Caillou Lake, whose salinities are relatively lower than typical saline marshes along the coast, would likely experience increased saltwater intrusion and marine influences resulting from breaches in the land bridge separating the gulf from Caillou Lake. Today, these saline marshes, with their lower salinity levels, allow for open water bottoms to serve as important oyster seed grounds.

Subprovince 4

In Subprovince 4, existing trends are expected to continue with saline marsh, intermediate marsh, fresh marsh, and swamp areas decreasing in percentage while brackish marsh and open water areas increase in percentage by 2050. The increase in water area percentage indicates a net land loss and a change in habitat diversity. Loss of portions of emergent wetland habitat is anticipated by 2050, primarily due to subsidence and hydrologic influences. Land acreage would continue to decrease, while vegetative productivity would increase slightly from Year 0 to Year 10, and then decrease through Year 50 (**figure MR2-13**).

Without action, the Sabine Lake wetlands, located near the Texas-Louisiana border, would continue to experience severe wetland deterioration and loss due to increased salinity levels and marine influences resulting from the Sabine-Neches Waterway and the GIWW. To the east, the freshwater, intermediate, and brackish marshes surrounding Calcasieu Lake would continue to experience severe wetland deterioration and loss due to increased salinity levels and marine influences resulting from the Calcasieu Ship Channel and the GIWW.

Wetland communities in the Mermentau Basin, located in the eastern portion of the Chenier Plain, would continue to be stressed and lost due to excessive water levels, or ponding. Conversely, the Grand Chenier wetlands, located to the south of the Mermentau wetland communities, would continue to experience deterioration and loss due to saltwater intrusion and a lack of riverine influence.

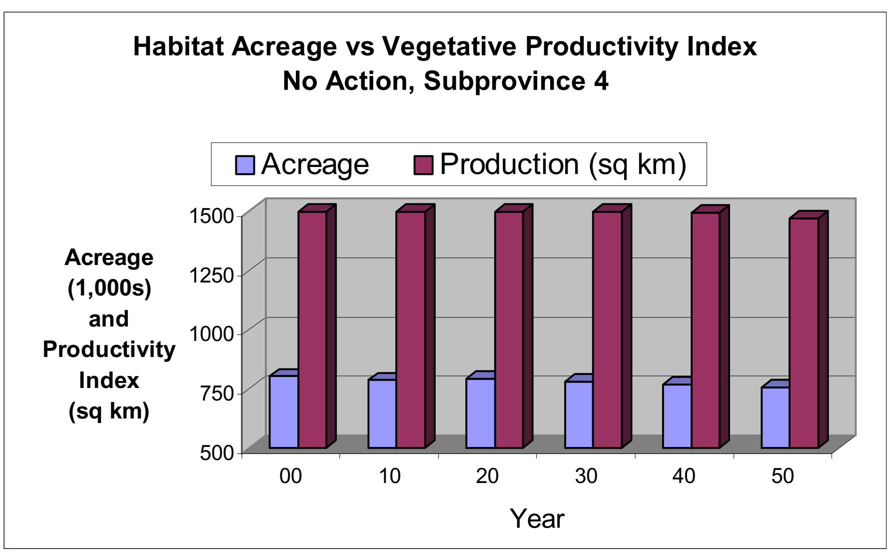

Figure MR2-13. Habitat Acreage and Vegetative Productivity for Subprovince 4 under Future Without-Project Conditions.

Barrier island systems

Without action, barrier island systems would continue to erode and, in many cases, disappear by 2050. Marine influences and tropical storm events would be the primary factors affecting land loss of the barrier island systems. As this land loss trend continues, hydrologic connections between the gulf and interior areas would increase and exacerbate land loss and conversion of habitat type within the interior wetland communities. Without the protective buffer provided by the barrier island systems, interior wetlands would be at an increased risk to severe damage from tropical storm events. In addition, critical habitats for threatened and endangered species and essential and diverse habitats for many terrestrial and aquatic organisms would continue to diminish.

While all the barrier island systems in the study area would continue to experience varying rates of land loss, the greatest occurrence is within the Barataria/Terrebonne shoreline, particularly the Isles Dernieres. Additional information on the barrier island systems can be found in appendix D LOUISIANA GULF SHORELINE RESTORATION REPORT.

2.2.3 Socioeconomic Analysis and Infrastructure

Nearly two million people, representing approximately 43 percent of the state's population, reside within the coastal area. The rich soil conditions, mild climate, natural waterways, and abundance of water and other natural resources have long attracted and supported economic development in coastal Louisiana. The diversified economy that exists in the region today includes oil and gas production and transportation, navigation, commercial fishing, agriculture, recreation, and tourism. Employment has varied widely with periods of rapid growth and contraction; in 2000 there were more than 800,000 jobs in coastal Louisiana. The most influential industries for the study area's economy include: oil, gas, and pipeline; navigation; commercial and recreational fishing and hunting; and agriculture, all of which are essential for supporting Louisiana's economy.

2.2.3.1 Oil, gas, and pipeline

2.2.3.1.1 *Existing conditions*

Louisiana plays an important part in the production of natural gas and crude oil for the Nation. Production of these resources in Louisiana occurs inland, in coastal areas, and offshore. In 2003, over one-third of the Nation's natural gas and more than one-quarter of the crude oil supply was produced in, processed in, or traveled through coastal Louisiana (LDNR 2003b). Louisiana's on-shore production of crude oil has declined by about 30 percent since 1980 although production in the Louisiana OCS has increased steadily since 1990 and now greatly exceeds the onshore production rate (**figure MR2-14**). The state's production of natural gas has remained essentially unchanged (**figure MR2-15**), yet its share of total U.S. production has increased. Interruption of the state's production of these two sources would have adverse socioeconomic impacts across the U.S. If U.S. energy consumption continues to increase and production remains constant, facilities located in the Louisiana coastal area will continue to be relied upon for the importation of additional energy.

Natural gas is the second largest source of energy for the United States. As with crude oil, Louisiana plays an important part in the production of natural gas for the Nation. Louisiana, Texas, and Oklahoma account for over half of all natural gas produced in the U.S. Louisiana produces slightly less total gas than Texas, but the majority of Louisiana production comes from offshore sources. Louisiana's natural gas production is currently greater than the total imported into the Nation.

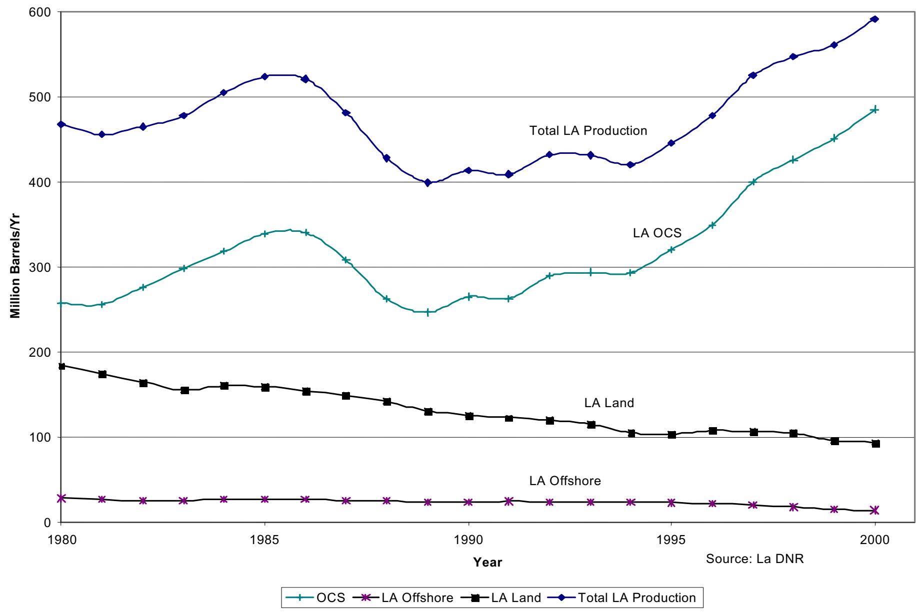

Figure MR2-14. Breakdown and Summary of Louisiana Crude Oil Sources.

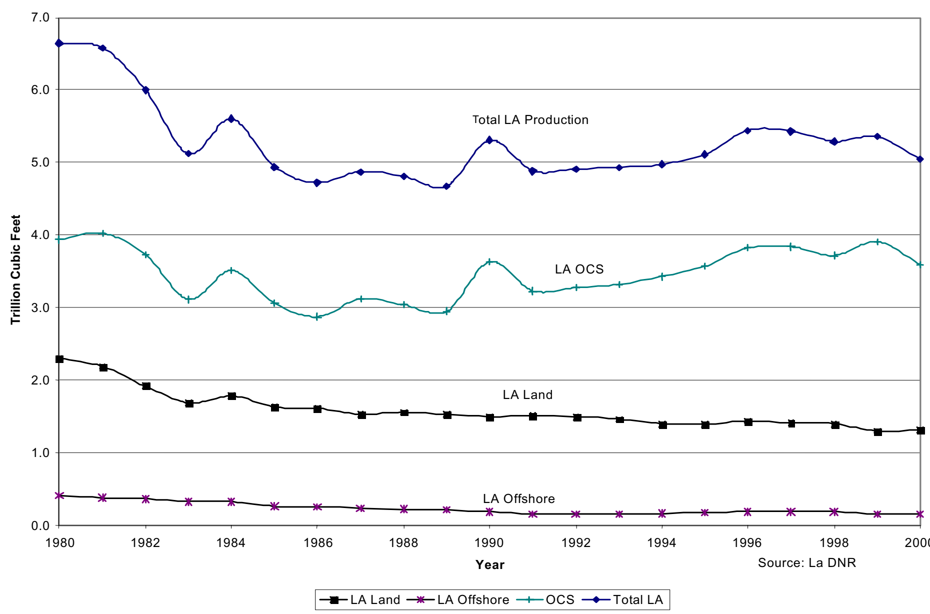

Figure MR2-15. Breakdown and Summary of Louisiana Natural Gas Sources.

Two of the four major storage facilities of the Nation's Strategic Petroleum Reserve are located in coastal Louisiana. Also, the Louisiana Offshore Oil Port (LOOP), 19 miles (30.6 kilometers) southeast of Port Fourchon, is the Nation's only Superport, serving as the central unloading and distribution point for incoming supertankers in the Gulf of Mexico. Louisiana's landscape is criss-crossed with thousands of crude oil, natural gas, and other liquid and gaseous hydrocarbon product pipelines (**figure MR2-16**). There are 13 major crude oil pipelines, 9 major product pipelines, and 13 liquefied petroleum gas pipelines in the state. Eighteen petroleum refineries distill a combined crude oil capacity of more than 2.7 million barrels per calendar day, which is the second highest in the Nation after Texas.

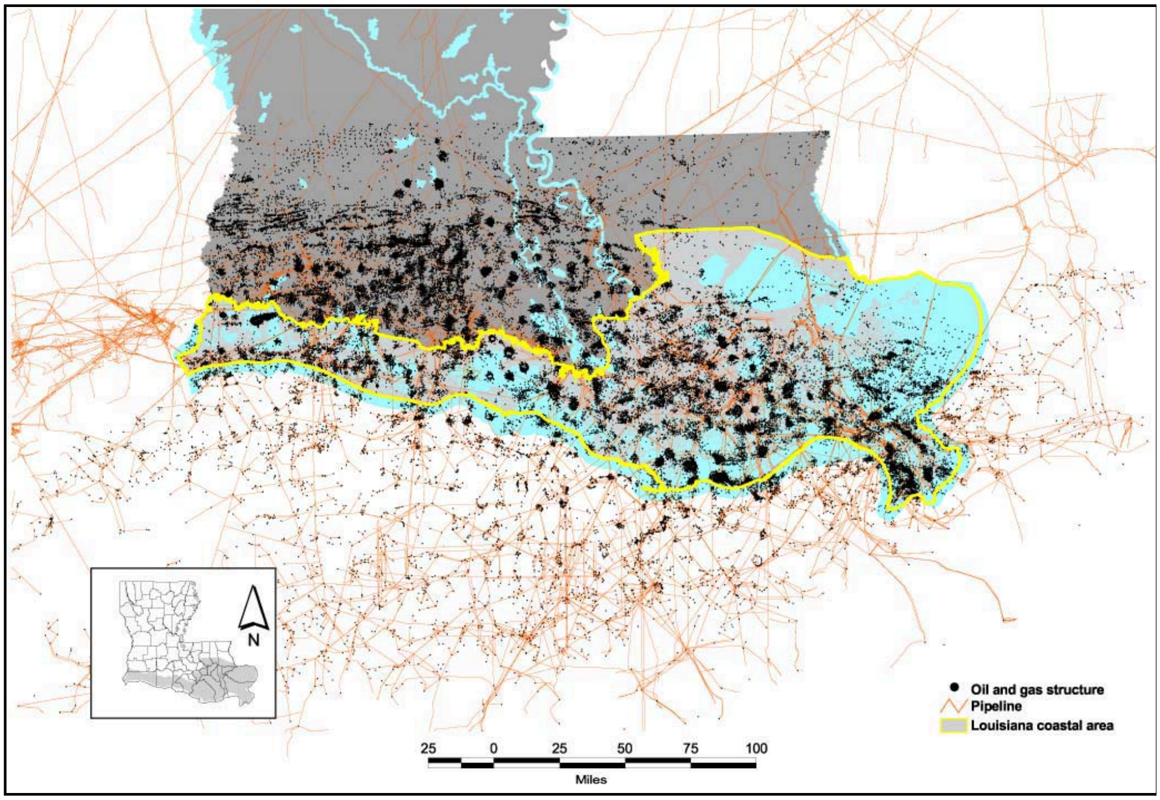

Figure MR2-16. Oil and Gas Structures and Pipelines within the Louisiana coastal area.

A study conducted by the Louisiana Mid-Continent Oil and Gas Association estimated that the direct and indirect impacts of the oil and gas industry on the Louisiana economy totals \$92.6 billion. The study also indicated that in Louisiana approximately 341,569 direct and indirect jobs are supported by the industry and that the industry is responsible for more than \$12.2 billion in household earnings (13 percent of total in Louisiana).

2.2.3.1.2 *Future without-project conditions*

Most of Louisiana's onshore oil and gas production occurs in the Louisiana coastal area. As previously discussed, this area is at an elevated risk due to the land loss and ecosystem degradation. Loss of wetland, marsh, and barrier islands presents a range of threats to inshore and offshore oil and gas infrastructure. Existing inshore facilities are not designed to withstand excessive wind and wave actions, which would become more commonplace as existing marshes are lost or converted into open bays. In addition, erosion and the subsequent disappearance of barrier islands would allow gulf type swells from tropical storm events to travel farther inland. The combination of these factors would increase the risk to inshore facilities. To address this risk, the oil and gas industry will be faced with the decision to invest in improvements to maintain production/transmission or, conversely, the closure and abandonment of infrastructure.

The offshore oil and gas industry in the coastal area is an important component in meeting National energy requirements. Coastal land losses have, and will continue to have, a negative effect on the extensive pipeline network located in coastal areas. As the open water areas behind the barrier islands increase in size, the tidal exchange volumes and velocities increase in the tidal passes and channels. This action can lead to the scouring away of sediment atop buried pipelines, exposing the pipelines and increasing the risk of failure or damage due to lack of structural stability, anchor dragging, and boat collisions. Resulting production or transmission shortfalls may result in disruptions in the availability of crude oil or natural gas to a significant part of the U.S. As the Caminada Headland continues to erode, Port Fouchon, a major oil and gas port and the terminus of the LOOP pipeline, would be at increased risk.

2.2.3.2 Navigation/shipping

2.2.3.2.1 *Existing conditions*

The ports and shipping lanes of coastal Louisiana serve as vital linkages between producers and consumers throughout the Nation and as gateways for international trade. Two of the Nation's most commercially important waterways in the U.S., the Mississippi River and the GIWW, traverse coastal Louisiana. On a ton-mile transported basis, the Mississippi River carries more cargo than any other navigable waterway in the country (Waterborne Commerce of the United States 2003). In addition, the Louisiana coastal area contains thousands of miles of coastal and inland waterways and numerous ports. The megaports of South Louisiana (stretching 54 miles along the Mississippi River), New Orleans, Baton Rouge, and Lake Charles are consistently ranked 1^{st}, 4^{th}, 9^{th}, and 13^{th}, respectively by annual U.S. port tonnage statistics. These ports handle approximately 14 percent of all U.S. crude oil imports and approximately 57 percent of all grain exports.

The Mississippi River from Baton Rouge to the Mouth of the Passes (Gulf of Mexico) is utilized by a variety of barge and ocean-going vessels and is one of the busiest waterways in the world. The river connects the megaports of South Louisiana, Baton Rouge, and New Orleans to the Gulf of Mexico. These intermodal port facilities support distribution and consolidation of goods and commodities between inland barge traffic, ocean-going vessels, and container facilities for truck and rail.

The GIWW intersects the Mississippi River at the Port of New Orleans. The GIWW provides safe and efficient shallow-draft navigation for all of the gulf states from the Texas/Mexico border to the western shore of Florida. In Louisiana, the GIWW spans 366 miles (589 kilometers) and is utilized by both small and large vessels to reach channels flowing into the gulf. The principle commodities moving on this waterway include chemicals, petroleum products, and crude oil. Many of these products are considered "red flag" (hazardous) cargos and cost less to move via waterway than truck or rail.

2.2.3.2.2 *Future without-project conditions*

A majority of Louisiana's navigable waterways would be adversely impacted without action as marshes and barrier islands that protect waterborne traffic on inland waterways continue to erode. As land adjacent to and connecting these waterways disappears, waterways currently protected would be exposed to wind, weather, and waves found in open bays and the Gulf of Mexico. Additionally, navigation channels that cross open bays may silt in more rapidly or begin to shoal in less predictable ways. The potential impacts to these waterways and the vessels that use them include increased maintenance costs (e.g., dredging), the necessity for higher horsepower vessels to counteract increased currents and wave forces, and increased risk of groundings, collisions, or storm damage to vessels and cargo. Moreover, shoaling causes the thousands of tows that traverse this area annually to slow down, thereby increasing both the transit time and cost of transportation. Due to increased safety concerns, alternate methods of transportation may have to be taken by hazardous commodities now utilizing the GIWW. These impacts would have a corresponding effect on cargo rates, which would affect the local and national economies.

Continued coastal erosion in south Louisiana could also increase the risk of obstruction or closure of the lower Mississippi River to navigation because of siltation or the loss of channel due to hurricane damage. Any closure of the river would result in increased operating costs of the ships waiting to enter or leave port as well as possible higher costs for inventory, additional storage costs, commodity flow restrictions, etc. It is estimated that a 7-day closure of the lower Mississippi River Navigation Channel would result in a loss of approximately $50 million, and a 14-day closure would result in a loss of approximately $200 million. These estimates only include increased operating costs of the ships waiting to enter or leave port. Additional costs would likely occur because of value of inventory, additional storage costs, commodity flow restrictions, etc.

2.2.3.3 <u>Commercial fishing</u>

2.2.3.3.1 *Existing conditions*

Louisiana's coastal estuaries are the most productive in the Nation. This large expanse of coastal wetlands and estuaries provides support during the critical life stages of important commercial species. As such, Louisiana has historically been an important contributor to the Nation's domestic fish and shellfish production, and one of the primary contributors to the Nation's food supply for protein. Dockside revenues in 2002 for commercial fisheries in coastal Louisiana, estimated at $343 million, were the largest for any state in the contiguous U. S. and second only to Alaska (NMFS 2003). They represent over 44 percent of the total dockside revenue for the gulf region and over 10 percent for the entire U.S. The estimated contribution of the commercial fishing industry to the state and National economies is $2.8 billion per year. Commercial fishing supports approximately 31,400 jobs in Louisiana alone.

Shrimp were the most profitable species in terms of Louisiana dockside revenue in 2001, valued at over $188 million. Almost all of the shrimp caught in Louisiana and along the gulf coast have spent key portions of their life cycle living and growing in the Louisiana coastal marshes. In fact, this habitat is critical for their development, making coastal habitats essential to the survival of all shrimp species in the Louisiana coastal area.

The Louisiana fishing fleet had over 14,000 vessels in 2001. Approximately 83 percent of these vessels were boats (under 5 tons) designed for inshore fisheries harvest. In 2001, there were 91 processing plants in the state, employing 2,239 residents, and 105 wholesale plants, employing 749 residents (NMFS 2003).

Important facts regarding the commercial fisheries in Louisiana include:

- The Louisiana menhaden fisheries landings were the largest in the Nation, twice as much as the next closest state. Menhaden is processed to produce both fishmeal and fish oil that is used as a high protein animal feed and for human consumption as an edible fat. In 2001, over 83 percent of the gulf catch and over 55 percent of the total U.S. catch was landed in Louisiana.
- Louisiana led the Nation in eastern oyster production, contributing just under half of the U.S. production. In terms of total (all species) oyster production in the U.S., Louisiana produced 37 percent of the Nation's oyster meats.
- Louisiana produced about 26 percent of the Nation's blue crabs in 2001. As with eastern oyster production, the trend has been for Louisiana to become the largest producer of blue crabs in the Nation.
- Louisiana produces almost half of the Nation's shrimp harvest. Shrimp landings in Louisiana were approximately 125 million pounds (56.8 million kilograms) during 2001, over 45 percent of total landings in the U.S.
- The Louisiana coastal wetland system represents critical breeding grounds for a variety of fish and shellfish species. It is estimated that over 75 percent of Louisiana's commercially harvested fish and shellfish populations are dependent on these wetlands during at least some portion of their lifecycle.

2.2.3.3.2 *Future without-project conditions*

Concurrent with projected land loss would be an increase in saltwater intrusion into the upper estuaries as barrier islands and marshes degrade. This would result in a shift in the populations of fishes and invertebrates, with more saline-dominated species replacing freshwater species. The band of intermediate salinity necessary for oyster production would likely narrow significantly, and essential fish habitat for many commercial fishery species would likewise decline, leading to a net loss in fisheries population size and diversity. Continued hypoxia could also adversely impact commercial fish landings.

Wetland habitat losses would decrease the productivity of Louisiana's coastal fisheries. The seafood industry would likely suffer significant losses in employment as estuaries, which are necessary to produce shrimp, oysters, and other valuable species, erode. Job losses would occur in the areas reliant on fishing, harvesting, processing, and shipping of the seafood catch. Thus, changes in existing fisheries habitat caused by wetland loss, saltwater intrusion, and reduced salinity gradients would likely increase the risk of a decline in the supply of nationally distributed seafood products from Louisiana's coast.

2.2.3.4 Agriculture

2.2.3.4.1 *Existing conditions*

Agriculture is an important component of coastal Louisiana's economy. More than $2.8 billion of crops and livestock were produced in Coastal Louisiana in 2001. The rich deltaic soil and mild climate are conducive to the production of a wide variety of crops, including sugar cane, rice, and soybeans. Much of this agricultural land is considered prime farmland and protected under the Farmland Protection Policy Act of 1981. Approximately 20 percent of the Nation's rice and 37 percent of the Nation's sugar are produced in Louisiana.

Timber production in Louisiana's forested wetlands is an important renewable resource. In 1996, the south delta region of Louisiana produced about 22 million cubic feet of lumber (Stratton and Westbrook 1996).

Agricultural production in the area has traditionally been supported by water obtained from the local bayous, but the bayous have recently begun to experience higher salinity levels, which is detrimental to crop production. In areas where saltwater intrusion has not occurred, the loss of adjacent wetlands and barrier islands makes croplands more susceptible to storm damages.

2.2.3.4.2 *Future without-project conditions*

Salinity levels in water used for crop irrigation is expected to increase in some areas, and with continued land loss, the risk of storm damage to agricultural resources would also increase. As the coastal landscape erodes and tidal surges force higher salinity waters farther inland, many areas would have to counteract this effect by relocating water intakes to more northerly locations or by installing saltwater barriers to protect their existing intakes. These expenses would undoubtedly be passed on to consumers.

Agricultural damages, including losses to crops such as sugar cane, rice, soybeans, pastureland, etc. associated with future without-project conditions were estimated along the Louisiana coast. This study indicated that continued loss of barrier islands and wetlands would increase the risk of storm damage to agricultural resources. The loss of agricultural productivity associated with reduced amounts of freshwater available for crop irrigation and increased risk of storm damages would result in adverse economic impact to Louisiana and the Nation.

2.2.3.5 Recreation

2.2.3.5.1 *Existing conditions*

The abundance of natural and cultural resources in the Louisiana coastal area supports a vast number and diversity of recreational activities. The present day recreational activities are deeply rooted in historical, vocational, and cultural traditions of southern Louisiana. The hundreds of local and regional festivals celebrated throughout the coastal area exemplify this with their focus on harvests of rice, sugar cane, shrimp, crawfish, oyster, and alligator. Other festivals celebrate the birds that pass through the state. The festivals also celebrate cultures and heritages such as Cajun, Native American, African American, and many European cultures.

The study area is also rich in renewable resources and serves as home to thousands of wildlife species that attract individuals for many types of recreational activities. From Texas to Mississippi, the recreating public has access to fresh, estuarine, and marine resources for fishing, hunting, boating, swimming, camping, bird watching, crabbing, and crawfishing. Additionally, the USFWS manages more than 300,000 acres (121,458 ha) of NWR lands in coastal Louisiana on behalf of the public. Traditional non-consumptive recreation includes, but is not limited to, tennis, golf, zoos, aquariums, baseball, picnicking, biking, cycling, RV-ing, camping, hiking, wildlife viewing, photography, and other activities. Nearly half of Louisiana's campgrounds, state historic sites, national historic parks, NWRs, WMAs, state parks and commemorative areas, important bird-watching areas, and other sites of interest are scattered throughout the coastal area.

Sportspersons and wildlife watchers across the U.S. spend $110 billion annually, 1.1 percent of the Nation's gross domestic product. Various studies have indicated that recreational fishing in Louisiana accounts for between $703 million and $1.2 billion per year in total expenditures (USFWS 2002; Gentner et al. 2001). Preliminary findings in the State of Louisiana, from the USFWS 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation, show that in 2000, 718,716 sportspersons participated in fishing and 3.8 million recreational fishing trips were made, with expenditures of $1.2 billion. Total hunting expenditures by Louisiana hunters in 2001 were $446 million, with big game expenditures comprising over half of the total. Wildlife-watching participants numbered 802,000 state residents and 38,000 non-state residents, with expenditures of $168.4 million. In this region of the country, 19 percent of the population are anglers, 9 percent are hunters, and 25 percent of the population participates in wildlife watching activities.

Americans traveling to Louisiana spent approximately $8.1 billion in 2001. This supported over 113,000 jobs in the state with annual income of about $1.8 billion. Tax revenues associated with recreation and tourism in Louisiana were about $1.1 billion for all levels of government. Thus, tourism is an important resource in the state of Louisiana.

2.2.3.5.2 *Future without-project conditions*

Recreational resources in the Louisiana coastal area that would be most affected in the future without-project condition are those that would be impacted by loss of wetlands and reduced habitat diversity and include some NWR lands managed by the USFWS in coastal Louisiana. Many recreational activities are based on aquatic resources and directly related to the habitat and species in an area. At the projected rate of land loss, the coastal area would experience the loss of 513 square miles (1,329 square kilometers) of existing marsh and swamp by 2050. Habitat changes affect wildlife populations, thereby affecting many recreational resources.

In general, wildlife abundance trends indicate a decrease in wildlife numbers where high rates of land loss occur and an increase in wildlife numbers where freshwater input or land building, often resulting from restoration projects, occurs. The populations of migratory birds and other animals directly dependent on the marsh and swamp would decrease dramatically, an impact which would be felt in much of North America. With the continued conversion of marsh to open water, fishery productivity (particularly estuarine-dependent species) is expected to peak, followed by a sharp decline.

The coastal area's changing environment would affect the recreational resources within that area. Where populations of freshwater or saltwater species decline, so would fishing (including crawfishing, crabbing, and oyster harvesting) opportunities. In areas where the populations of game species fluctuate, so would the hunting opportunities. As populations of migratory birds are affected, so would the opportunities for viewing them.

As existing freshwater wetland areas convert to saltwater marsh, then to open water, the recreational opportunities would change accordingly. For example, freshwater fishing opportunities may become saltwater opportunities. If the expected peak and subsequent decline of fishery production occurs in these open waters, the associated marine fishery recreational opportunities would also decline. As populations of migratory birds and other animals dependent on marsh and swamp decrease, associated recreational opportunities, such as hunting and wildlife viewing, would decrease.

Another major impact of land loss would be the possible loss of facilities and infrastructure that support or are supported by recreational activities. Land loss and the increased risk of storm damage can directly result in the loss of boat launches, parking areas, and access roads, as well as marinas and supply shops. The loss of access features, such as roads and boat launches, would directly impact the public's ability to recreate.

2.2.3.6 Cultural resources

The USACE is obligated under the National Historic Preservation Act (NHPA), as amended (16 U.S.C. 470 et seq.), and NEPA to take into account the effect its undertakings have upon cultural resources within a given project area. Under these laws and regulations, the USACE assumes responsibility for the identification and evaluation of all cultural resources within the project boundaries. In addition, the USACE must afford the State Historic Preservation Officer (SHPO), and on occasion the Advisory Council on Historic Preservation (ACHP), the opportunity to review and comment upon proposed undertakings and associated cultural resource investigations.

2.2.3.6.1 *Existing conditions*

Humans have made a progressive mark on the lower Mississippi Valley and coastal Louisiana for thousands of years. Archaeological remains found in Louisiana indicate that man has occupied the area since around 10,000 B.C., primarily as nomadic hunter-gatherers that migrated with the fluctuations of the Mississippi River. European settlement of the lower Mississippi Valley and coastal Louisiana began between 1698 and 1763. During that time, permanent settlements were established along the primary means of transportation in the area, the Mississippi River. As population along the Mississippi River increased, land along its natural levees became scarce and new settlements began to be established on other waterways such as bayous Lafourche, Teche, and Terrebonne, and the Vermilion River. Shortly after European settlement along the Mississippi River and other waterways, the network of levees and canals currently used across coastal Louisiana for flood control and navigation began to take shape.

As previously mentioned, the diverse resources available in coastal Louisiana have led to a diverse history and rich culture in the Louisiana coastal area. As a result, cultural resources are abundant in the area. Over the last 50 years, as land loss has progressed and saltwater intrusion has increased, many of these cultural resources have been put at risk or lost to erosion, inundation, and construction of canals.

The 20 coastal parishes of the LCA study area contain thousands of cultural resources. The Louisiana State Historic Preservation Office is charged with the responsibility of maintaining the central files of all the archaeological and historical standing structures data. All cultural resources survey reports and forms conducted under the NHPA are archived in their offices in Baton Rouge.

2.2.3.6.2 *Future without-project conditions*

As inland marshes and barrier islands erode or subside, cultural resources existing on them could be exposed to elements or inundated, putting them at a greater risk of damage or destruction. Resources could also be adversely impacted over time by an increased risk of storm damage as barrier islands and marshes continue to degrade. Cultural resources would continue to be affected as historical and archaeological sites are exposed to these forces.

2.3 PROBLEMS, CRITICAL NEEDS, AND OPPORTUNITIES

2.3.1 Problems

The natural processes of subsidence, habitat switching, and erosion of wetlands, combined with a widespread human alteration, have caused significant adverse impacts to the Louisiana coastal area, including increased rates of wetland loss and ecosystem degradation. Without action, Louisiana’s healthy and highly productive coastal ecosystem, composed of diverse habitats and wildlife, is not sustainable. Construction of levees along the Mississippi River has cut the coastal ecosystem off from a primary source of sediment and nutrients, and hindered the wetlands' ability to maintain their elevation in the face of sea level change and subsidence. This accompanying reduction of freshwater input has enabled saltwater to intrude into more sensitive freshwater habitats. Confinement of the Mississippi River to a channel has also resulted in the bed sediment load of the river being deposited in progressively deeper waters of the Gulf of Mexico; from these locations the sediment cannot efficiently nourish the coastal barrier shorelines. These shorelines are starved for sediment and are retreating. Infrastructure constructed for access into and across the wetlands has modified the hydrology of the coastal area, thus facilitating and accelerating saltwater intrusion and conversion of wetlands to open water. In addition, there has been a decline in the measured sediment load delivered by the Mississippi River from the rest of the drainage basin in the last 50 years.

These alterations have impacted the natural sustainability and quality of the Louisiana coastal ecosystem. This loss of sustainability has manifested itself as accelerated land loss. If recent loss rates continue into the future, even taking into account current restoration efforts, coastal Louisiana is projected to lose an additional 328,000 acres (13,284 ha) of coastal marshes, swamps, and barrier islands by the year 2050. Today, the high biological productivity of the coastal wetlands, most visibly expressed in abundant waterfowl and commercial and recreational fishery resources, masks the potential for a downward trend in biological productivity and coastal ecosystem health. The best available science on deltaic processes illustrates that biological productivity is highest during periods of wetland conversion and degradation, and that the current level of high biological productivity is unsustainable (**figure MR1-7**). Unless the trend of accelerated land loss is reversed, the health and productivity of the coastal ecosystem cannot be sustained.

The loss of wetlands could result in ecosystem conversion to open water by placing the following ecosystem functions at risk:

- Vegetative habitat suitability and community diversity;
- Elevational maintenance and soil contribution from decomposing organic material;
- Protection against substrate erosion;
- Water quality improvement;
- Nutrient uptake and carbon sequestration;
- Important nursery habitat;
- North American Central Flyway and North American Mississippi Flyway waterfowl wintering habitat; and
- Resting and feeding areas for neotropical migrants.

The abundance and diversity of aquatic and terrestrial habitat types affects the biological productivity of the fish and wildlife resources in the estuarine-marsh complex. Measurement of the relationship between habitat and productivity of all resources is difficult and can best be discussed primarily in qualitative terms; that is, a beneficial or an adverse change in environmental conditions is followed by a corresponding change in productivity. However, the relationship of marsh vegetation to the productivity of the commercial fish and wildlife resources has been documented. Biologists generally agree that habitat reduction would be accompanied by diminished harvests (Craig et al. 1979). Shrimp and menhaden yields have been correlated directly to the area of intertidal wetlands (Turner 1979). Neotropical and other migratory avian species have been shown to depend on habitats that are in need of restoration and management in the coastal area (Barrow et al. 2000; Helmers 1992).

Land loss and ecosystem degradation also threaten the continued productivity of Louisiana's coastal ecosystems, the economic viability of its industries, and the safety of its residents. The following valuable social and economic resources could be impacted:

- Commercial harvest of fishery resources;
- Oil and gas production;
- Petrochemical industries;
- Recreational saltwater and freshwater fisheries;
- Ecotourism;
- Agriculture;
- Strategic petroleum reserve storage sites;
- Flood control, including hurricane storm surge buffers;
- Navigation corridors and port facilities for commerce and national defense; and
- Actual and intangible value of land settled 300 years ago and passed down through generations.

2.3.2 Critical Needs

The cumulative effect of human activities, both past and present, has been to tilt the balance between land building and land loss in the direction of net land loss. The reintroduction of riverine processes and resources, as well as the management of activities within the coastal area consistent with the objectives of wetland restoration, is needed to achieve a balanced and sustainable system. Consistency in operation and management of all existing and future measures and activities to optimize multiple system outputs would be required to ensure the success of any restoration program.

Critical needs in the study area include:

Prevent future land loss where predicted to occur

Addressing this need would create and sustain diverse coastal habitats, sustain wildlife and plant diversity, and sustain socio-economic resources. Effective measures to reverse coastal land loss should affect plant communities, in their root zone, in such a way as to promote healthy growth and reproduction, plant succession, or revegetation of denuded surfaces. Increasing nutrients and sediment in the estuarine area would increase the growth of marsh vegetation and slow the rate of land loss. Increased plant growth would result in greater production of organic detritus that is essential for a high rate of fisheries and wildlife production. Production of phytoplankton and zooplankton would increase in areas where turbidity is not limiting, and, as a result, the harvest of sport and commercial finfish and shellfish that depend on these microorganisms would increase.

Restore fundamentally impaired or mimic deltaic processes through river reintroductions

Addressing this need would reduce habitat deterioration by increasing nutrients and sediment delivered to the estuarine-marsh areas, which would increase marsh vegetation sustainability and improve fish and wildlife production. In addition, restoring riverine influences to coastal wetlands and creating wetlands would help address the need to reduce the nutrient loading into the northern gulf and to reduce the hypoxic zone. This need can be met by restoring or mimicking distributary flows, crevasses, and over-bank flow, as well as mechanical marsh creation with river sediment, if sustained by freshwater diversions.

Restore or preserve endangered critical geomorphic structures

Addressing this need would restore geomorphic structures, such as natural levee ridges, lake rims, land bridges, gulf shoreline barrier islands, barrier headlands, and chenier ridges. These features are essential to maintaining the integrity of coastal ecosystems because they are an integral part of the overall system and in many instances represent the first line of defense against marine influences and tropical storm events.

Protect vital local, regional, and national socio-economic resources

Addressing this need would reduce the increased risk of damage to cultures, communities, infrastructure, business and industry, and flood protection. Accelerated land loss and ecosystem degradation places over $100 billion of infrastructure at increased risk to damage as a result of storm events. This need could be met by increasing the marsh's capacity to buffer hurricane-induced flooding through wetland creation and sustenance and retention of barrier island systems.

2.3.3 Opportunities

The resources of the Mississippi River system remain available to contribute to the restoration of the coastal Louisiana ecosystem. The Federal Government and State of Louisiana have been conducting ecosystem restoration efforts for the past 14 years under the CWPPRA. In addition, the scientific community in Louisiana is recognized internationally for their expertise in climate and wetland research. The lessons learned and extensive experience gained from past restoration and research efforts have been applied in the LCA Study and can continue to be applied in a systematic way to develop and implement a coast wide plan for addressing the land loss problem and critical needs facing coastal Louisiana. Opportunities for ecosystem restoration include:

- Freshwater reintroductions and outfall management - Diverting water from the Mississippi River into hydrologic basins can 1) nourish existing marshes to increase their productivity and build wetlands in areas of open water, 2) potentially reduce the extent of the hypoxic zone in the gulf, 3) help satisfy the need for maintaining salinity gradients that correspond to the diversity of vegetative habitat, and 4) reintroduce and distribute sediment and nutrients throughout the ecosystem;

- Barrier island restoration, through placement of sand from offshore sources or the Mississippi River, could sustain these geomorphic structures, which would provide additional protection from hurricane storm surges and protect the ecology of estuarine bays and marshes by reducing gulf influences, as well as protect Nationally important water bird nesting areas;
- Hydrologic modification, such as degrading excavated dredged material banks or re-establishing ridges or natural banks, can help restore salinity and marsh inundation patterns and provide fishery access in previously unavailable habitats; and
- The use of sediment material from dedicated dredging or maintenance dredging (e.g., beneficial use) to create a marsh platform can create large amounts of coastal habitat quickly.
- Many of the above techniques can be applied in combination to produce synergistic effects while minimizing disruptions to the surrounding ecology and economy (e.g., dedicated dredging in conjunction with a small river diversion to increase the sustainability of the created marsh).

By applying ecologically sound principles and restoration methods developed in recent years, and through improved understanding of coastal system processes and ecosystem responses to restoration projects, there is an opportunity available for Louisiana and the Nation to reverse the current trend of land loss and move the Louisiana coastal area ecosystem toward a sustainable future.

2.3.3.1 Freshwater and sediment diversions

There is an opportunity to use riverine resources, such as freshwater, sediment, and nutrients, transported down the Mississippi River and its distributaries to reverse coastal land loss, restore hydrologic connectivity, and improve ecosystem function. Controlled diversions into marshes with water depths averaging about 5 feet (1.5 meters) or less would require relatively less sediment for each acre (hectare) of new land and would likely be more effective in counteracting land loss than the building of sub-deltas in relatively deep water. Mimicking crevasses through reintroductions into waters with depths of approximately 12 feet (3.7 meters) may be a practical and effective means of creating land in bays and sounds adjacent to the Mississippi River, but would require substantially more sediment for each acre (hectare) of marsh created.

In creating new land, it is not desirable to completely fill the receiving water bodies. Rather, it would be more desirable to transform large lakes and bays into a series of interconnecting ponds with shallow water depths. Judicious spacing of the sub-delta lobes would substantially increase the land/water interface, which is more attractive to marsh and estuarine life forms. The introduction of sediment should be carried out periodically. This would allow plants and animals to enter and establish themselves in the newly made areas shortly after the land is formed.

In addition to freshwater diversions, hydrologic restoration can also be accomplished through salinity control management in areas where riverine sources are less abundant, such as in the Chenier Plain.

2.3.3.2 Beneficial use of dredged materials

The beneficial use of dredged material can also reduce land loss. The USACE-Mississippi Valley, New Orleans District (District) excavates an average of 70 mcy (53.5 million cubic meters) of material annually in maintenance dredging of navigation channels. A major portion of this volume is either re-suspension or hopper dredged material, however, and is therefore not available for beneficial placement. The District, along with other Federal and state local cost sharers, has beneficially placed dredged material to create over 18,000 acres (7,200 hectares) of land between 1976 and 2003..

Sediment will be tested as appropriate on a project specific basis. Furthermore, the Clean Water Act 404 (b)(1) Guidelines (40 CFR 230) are the environmental criteria for evaluating the proposed discharges of dredged or fill material into waters of the U.S. Compliance with these guidelines is the controlling factor used by the USACE to determine the environmental acceptability of disposal alternatives. The USACE must demonstrate through completion of a 404 (b)(1) evaluation that any proposed discharge of dredged material is in compliance with the Guidelines.

2.3.3.3 Nearshore and offshore sand resources

Barataria offshore sand resources

Identification of sand resources to support the coast wide restoration of Louisiana's barrier islands and back-barrier marshes requires finding large volumes of high-quality sand and developing cost-effective delivery systems to move these materials. The recent cooperative study by the USGS, the University of New Orleans, and USACE (Kindinger et al. 2001) as part of the Barataria Feasibility Study provides such information for the offshore Barataria Basin area.

Seismic and sonar interpretations, verified by geologic core samples, confirm that there are several nearshore sand bodies within the Barataria offshore area that meet or exceed the minimum criteria for potential mining sites. These sand bodies potentially contain between 396 and 532 mcy (303 to 407 million cubic meters) of sand and can be characterized into surficial and buried sites. However, while these potential sand sources consist primarily of fine sand, a full 90 percent of the sand body areas will need almost 570 mcy (436 million cubic meters) of overburden removed if the entire resource is mined. Kindinger et al. (2001) recommend using the sand for barrier island shoreface restoration and the overburden to build back-barrier platforms for marsh restoration. The researchers also recommend consideration of Ship Shoal as an alternative resource.

Terrebonne/Timbalier offshore sand resources (Ship Shoal)

Ship Shoal, the largest submerged shoal off Louisiana, is a sand body located on the south-central Louisiana inner shelf about 9.5 miles (15.3 kilometers) seaward of the Isles Dernieres. Ship Shoal is approximately 31 miles (50 kilometers) long and 3 to7.5 miles (4.8 to

12.1 kilometers) in width, with relief of up to 12 feet (3.6 meters). Water depth ranges from 23 to 30 feet (7 to 9 meters) on the eastern side of the shoal to approximately 10 feet (3 meters) over the western reaches (Penland et al. 1986). It is composed primarily of well-sorted quartz sand, a benthic substrate not commonly found on the Louisiana inner shelf (Stone 2000) and, as the name implies, may have significant historical sites associated both within and on its surface. The Minerals Management Service (MMS) recently completed an environmental assessment on proposed dredging of sand from Ship Shoal for coastal and barrier island restoration projects and for flood levee construction. This analysis determined that the proposed action to dredge and emplace sand from Ship Shoal would not significantly affect the quality of the human environment.

2.3.3.4 Availability of coastal wetlands to remove nutrients

In January 2001, the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force issued the *Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico* (Action Plan). According to the Action Plan, restoring and enhancing de-nitrification and nitrogen retention in the Mississippi River Basin, including the Deltaic Plain in southeastern Louisiana, are the primary approaches for reducing gulf hypoxia. Mitsch et al. (2001) also identify Mississippi River diversions as a tool for reducing gulf hypoxia, and estimate that potential nitrate reduction using diversions "is probably limited to less than 10 percent to 15 percent of total flux in the river."

Preliminary results of earlier coastal area water quality modeling efforts (see appendix C HYDRODYNAMIC AND ECOLOGICAL MODELING) along with existing literature on the subject (Mitsch et al. 2001) suggest that large-scale river diversions may contribute significantly to the National effort to reduce hypoxia in the northern Gulf of Mexico. Because some river diversion features evaluated during plan formulation are relatively small, implementation of such projects would likely result in nutrient reductions that are small in comparison to total nutrient inputs from the Mississippi River to the gulf. Implementation of a LCA Plan would, however, provide an excellent opportunity to add to our understanding of the effectiveness of river diversions in reducing nutrient inputs from the Mississippi River to the Gulf of Mexico, while also further studying any potential adverse effects of such projects. In this way, the lessons learned from implementation of the river diversion features could facilitate large-scale river diversion projects in the future, along with the potentially significant nutrient reductions such projects might provide.

This page intentionally left blank.